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THE ECONOMIC STATUS OF SCIENTIFIC MEN AND WOMEN.[1] II

SALARY SCALES OF TRAINED MEN AND WOMEN

By Professor RODNEY H. TRUE

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THE organization of the Committee of One Hundred on Scientific Research at the Washington meeting marked an interesting departure from the usual policy of the American Association for the Advancement of Science. It had always concerned itself directly with the consideration of problems of research in the several sciences, but had not taken cognizance of the conditions of research. The Committee of One Hundred was organized to study the problems of the researcher. Among the several factors that weigh heavily in determining his success are those of adequate equipment, free time to devote to the work and a mind free to apply itself to the rather exacting work of research.

We are told that financial resources have now been enlisted sufficient to adequately supply the needs of a large body of high-grade research work and that universities and colleges are giving more generous support to this aspect of their work.

We are also told that in some universities and colleges the teaching load and other duties crowd into the resources of time and energy to such an extent as to greatly reduce or even extinguish research.

We hear from many quarters that inadequate salaries are being paid in academic institutions with consequences hostile to research. We hear that the denials forced on college and university teachers by salary inadequacy force them to sell more or less

[1] Symposium of invited papers read before a general session of the American Association for the Advancement of Science, New York, December 28, 1928.

of their time to earn added income, to the detriment of research. We hear the opinion expressed with emphasis that this has now gone on long enough to have its effect on the class of men and women filling academic positions. It is asserted that second-rate and third-rate men are now more numerous in our faculties than heretofore with the disconcerting outlook toward lower standards in our higher educational institutions facing us.

The subcommittee on the economic status of the scientific worker has sought to investigate the questions of salary in the hope of establishing the facts in the case.

A survey of salaries actually paid to members of college and university faculties will give us something definite to work with. Whether these salaries are equal to those paid to trained men and women in other lines of work likely to compete with colleges and universities for the efforts of the best of the young leaders who may be choosing for themselves a life work may in a measure be shown by a comparison of academic salaries with those paid elsewhere for trained men.

The sum of money received does not always permit one to judge whether or not the income is adequate. The needs must be set up against the purchasing power of the income in order to judge adequacy. Consequently a study of the budgets of academic families seems to be needed if we are to assert much regarding the adequacy or inadequacy of salaries.

In the following paper are presented data gained from a study of the salary scales paid to trained men and women in several lines of work. A variety of academic institutions are considered in appropriate groupings, commissioned officers of the army and navy, the civil service employed by the national government in Washington and in the field, and a considerable group of manufacturing enterprises that form the final training school and goal for great numbers of young men who go into business.

The figures here tabulated have been carefully collected from official or other sources believed to be trustworthy and are thought to be substantially correct for the present time. Certain of these groups have undergone considerable change within the last year or two and may be changed again, hence these figures are of temporary accuracy.

ACADEMIC INSTITUTIONS

The situation with the academic group from different parts of the country will be indicated first. State universities, endowed universities, found chiefly in the east, colleges mainly located east of the Mississippi River and agricultural colleges from all parts of the country have been dealt with. The list is not always complete but is believed to be long enough to be fairly representative.

In the list of salaries, positions from the president to the instructor have been included, since the college or university is an organized enterprise and obeys much the same psychological laws regarding the distribution of responsibility as army units or manufacturing enterprises.

State universities. The state universities form a rather natural group because of the official character of their support, because of their necessarily close relation to the school systems of which they are the crown and because of the possible political and other influences to which they are in some measure subject. Since these institutions are usually of rather late origin, they are most strongly developed in the younger and often times more vigorous states.

In Table I are shown the salary ranges reported from thirty-six state universities for the several faculty grades indicated. In most institutions there is a salary that is regarded as "normal" for each grade. Sometimes this is near the medium range, sometimes below it. This sum was set by the authorities replying to the questionnaire.

TABLE I

SALARIES PAID BY 36 STATE UNIVERSITIES

	Minimum	Maximum	Average
President	$5,000	$22,800	$11,597
	Average Minimum	Average Maximum	Average Normal
Deans	$3,916	$ 6,331	$ 5,085
Professors	3,024	5,321	3,813
Associate professors	2,670	3,878	3,100
Assistant professors	2,106	3,388	2,510
Instructors	1,436	2,695	1,869

Some very interesting results would come out of various analyses of the data at hand, but this task must be deferred.

Agricultural colleges. Closely allied to the state universities are the colleges of agriculture and mechanic arts. These institutions are wholly or in large part supported by state and federal funds, and for a special type of training stand in a similar relation to their constituency as does the state university to general education. Owing in part to the late origin of these schools and in part to the differing importance of agriculture in different sections, these schools have been more strongly developed in the great agricultural states of the middle west than has been the case in the manufacturing east.

It is difficult to get a complete picture of this group, owing to the fact that some of them are corporate parts of the state universities and can not be separated in any clear-cut way from them. For present purposes only those schools that are maintained as separate institutions are included here.

Data are presented from twenty such schools, five from each of the four large areas of the country.

TABLE II

SALARIES PAID BY 20 COLLEGES OF AGRICULTURE AND MECHANIC ARTS

	Minimum	Maximum	Average
President	$6,000	$17,000	$9,150
	Average Minimum	Average Maximum	Average Normal
Deans	$4,110	$5,381	$4,992
Professors	2,792	4,350	3,609
Associate professors	2,379	3,310	2,871
Assistant professors	2,032	3,042	2,406
Instructors	1,482	2,332	1,822

Endowed universities and colleges. Among the older states higher education was often begun and supported by private gifts. These institutions were sometimes established to support the opinions of special groups or parties. As time has passed they have largely lost the group label but have continued to rely on the gifts of friends. In so doing they have kept out of certain entangling alliances and have become powerful in the academic family. For historical reasons, they are strongest, generally speaking, where state support has been undeveloped, and have their maximum growth in the east.

Full data concerning privately supported institutions have not always been obtainable for this study. Why salaries should be regarded as a matter of secrecy is a proposition that might lead to speculation. No attempt has been made to secure data from all endowed colleges and universities, but the group here presented is believed to offer a fair comparison with the other groups dealt with. It is realized that in the other classes the small private colleges have no homologs and hence are not adequately represented in this presentation.

In order to get a general view of the salary situation as it stands with the groups of academic institutions here dealt with, I have averaged the average rates given in the first three tables. I realize that this resulting average is not strictly a weighted average but offer it as an approximate summing up of the situation.

TABLE III

SALARIES IN 12 ENDOWED UNIVERSITIES AND COLLEGES

	Minimum	Maximum	Average
President (3)	$11,500	$12,000	$11,833
	Average Minimum	Average Maximum	Average Normal
Dean	$	$	$
Professor (12)	4,571	7,033	5,856
Associate prof. (11)	3,855	4,368	4,293
Assistant prof. (12)	2,730	3,996	3,356
Instructor (12)	1,617	2,823	2,180

TABLE IV

COMPOSITE FOR ACADEMIC SALARIES

	Average Minimum	Average Maximum	Average
President	$7,500	$17,267	$10,860
Dean			
Professor	3,462	5,568	4,425
Associate professor	2,964	3,852	3,421
Assistant professor	2,289	3,509	2,757
Instructor	1,512	2,616	1,957
Averages for teaching faculty	2,557	3,886	3,140

The average salary of a member of the teaching faculty drawn from the records of the groups here dealt with, in all sixty-eight institutions, is about $3,140. This is only an approximate result because of the small number of institutions included.

PROFESSIONAL AND SCIENTIFIC SERVICE OF THE UNITED STATES GOVERNMENT

The scientific and technical services of the national government require the most varied kinds of scientific training and experience and constitute probably the largest organized body of scientific workers in the world. The Department of Agriculture, the Bureau of Standards, the Geological Survey and the Bureau of Mines among others form important sources of demand for men and women trained in the colleges and universities. The government service has suffered from low salaries and from various weaknesses due to methods of administration. The salary situation is improving as a result of the Reclassification Act of 1923 and the recent amendment growing out of the Welch Bill, until the average salary of workers in the professional and scientific grades in Washington belonging to the Department of Agriculture has reached the sum of $3,894, an amount greater by $754 than the average salary of members of the teach-

ing faculties in the sixty-eight colleges and universities above considered. This advantage seen in the government service is a relatively recent one, due largely to the average advance of over $500 since 1924.

When the Reclassification Act went into effect, the kinds of work having approximately similar requirements were brought together into a series of grades for which duties were broadly defined and for which compensation was fixed on a sliding scale. I have brought together in Table V the several grades designated in the Amending Act of 1928 with the salary range in each grade. Since shifts are constantly being made within the grades, no attempt has been made to establish a weighted average for the employees of these grades, but there are brought together the figures indicating the limits between which salaries in the grade vary. Since the requirements for filling these positions through civil service examinations are based more or less definitely on the formal steps in college or university education, the latter equivalents are indicated in order to give the academic latitude and longitude of these groups of government employees.

TABLE V

SALARY RANGE OF GRADES IN THE PROFESSIONAL AND SCIENTIFIC SERVICE OF THE NATIONAL GOVERNMENT

Grade	Designation of grade	Minimum salary	Maximum salary
9	Special professional grade	$9,000 above	$9,000
8	Chief professional grade Heads of large bureaus	8,000	9,000
7	Head professional grade Assistant bureau head	6,500	7,500
6	Principal professional grade Head of smaller organizations	5,600	6,400
5	Senior professional grade Project leaders	4,600	5,200
4	Professional grade under general supervision	3,800	4,400
3	Associate professional grade Investigator (Ph.D.)	3,200	3,700
2	Assistant professional grade (M.A. or M.S.)	2,600	3,100
1	Junior professional grade (College graduate)	2,000	2,500

Assisting the investigators in the professional and scientific grades are workers whose previous education and experience are less than that of a graduate from a college or university of recognized standing. This is called the subprofessional service and interests us here chiefly because of the salaries paid. Again eight grades are indicated with duties decreasing in requirements from Grade 8. These are usually laboratory assistants who have had training in college or in high school or its equivalent elsewhere.

TABLE VI

SALARY RANGE OF SUBPROFESSIONAL SERVICE (SCIENTIFIC GROUP)

Grade designation		Minimum	Maximum
Grade 8	Chief, subprofessional most difficult technical work, two years college	$2,600	$3,100
7	Principal subprofessional very difficult technical work	2,300	2,800
6	Sr. subprofessional difficult technical work	2,000	2,500
5	Main subprofessional responsible technical work	1,800	2,100
4	Asst. subprofessional ordinary technical work, one year college	1,620	1,920
3	Jr. subprofessional supervised usual work high school	1,440	1,740
2	Under subprofessional supervised simpler work common school	1,260	1,560
1	Minor subprofessional simplest routine work common school	1,020	1,320

It will be noted that these laboratory assistantships filled by men and women who have gone beyond the high school but who have not graduated from college command salaries varying from $1,800 to $3,100, overlapping the salaries paid to instructors and even that usually paid to assistant professors. Associate professors, on the average, do not exceed the maximum of Grade 8 of the subprofessional service at Washington.

UNITED STATES ARMY

The commissioned officers of the army constitute another group of trained men. Many of them are West Point graduates, while many others have gained their rank through other training. The army is one of the vocations to which young men of ambition turn. In it are steady pay, a chance for advancement and perhaps for stirring adventure. The social position of the officer is a strong inducement to many. The living expenses are in considerable part met outside of salary, and after retirement, at an age that leaves

one still much to look forward to, the retirement allowance of three fourths of the last salary will keep the wolf from the door. Some having no fondness for the bloody side of the business may see little chance for either killing or being killed and appreciate the good points sufficiently to join. Here length of service is recognized by longevity pay, and allowances for rental and subsistence are added to the pay. Moreover the liberal reduction in prices at the government stores or commissaries do much to "stretch" the salary income.

In Table VII is shown the pay scale of the commissioned officers of the army. In calculating minimum and possible maximum pay rates, I have added to the base pay the allowances for rent and subsistence and such additions as come with length of service. In calculating minimum pay allowances I assume no dependents. In the case of maximums, dependents are assumed. No account has been taken of advantages derived from buying at the commissary owing to the great number of variable factors.

TABLE VII

PAY SCALE OF COMMISSIONED OFFICERS OF THE ARMY

Rank	Minimum pay	Maximum pay
General	$13,500 plus confidential allowances	
Major-general	9,176	$9,700 (legal limit)
Brigadier-general	7,176	7,500 " "
Colonel	4,676	7,200 " "
Lieutenant-colonel	3,936	7,200 " "
Major	3,336	7,200 " "
Captain	2,696	5,348
First lieutenant	2,196	4,992
Second lieutenant	2,196	4,150

UNITED STATES NAVY

The pay scales of the commissioned officers of the U. S. Navy are subject to the same general considerations as have been advanced in connection with those of the army officers. Length of service is recognized in ranks below the rear admiral, substantial allowances for rental and subsistence are made and retirement on a generous pension are found. The navy too has its commissary at which officers may buy at a marked reduction in price.

In view of the pay scales seen here for the officers of the army and the navy, the question occurs to one, why do the ambitious and in this case not too idealistically inclined young men turn to these lines of activity for their life work? Apart from the possibility for adventure that may appeal to some, the financial inducement is greater than shows on the pay scales. Officers are retired at three fourths of the

TABLE VIII

PAY SCALES OF COMMISSIONED OFFICERS OF THE NAVY

	Without dependents	With dependents
Admiral	$11,379	$11,900
Vice admiral	9,679	10,200
Rear admiral (upper half)	9,179	9,700
Rear admiral (lower half)	7,179	7,500

	Minimum	Maximum
Captain	$4,679	$7,200 (legal limit)
Commander	3,939	7,200 " "
Lieut. commander	3,339	7,200 " "
Lieutenant (senior)	2,699	6,357
Lieutenant (junior)	2,199	4,998
Ensign	2,199	4,158

pay received at the time of retirement. When one sees what these pensions are equivalent to as successfully invested savings in the case of the teacher, it is clear that the pension is a very potent financial argument.

A major with dependents in the active service after twenty-four years draws in pay and allowances $6,988. Such a major retires on $3,675, three fourths of his pay (allowances being excluded). For a teacher to provide himself a similar income would mean a saving of $73,500 safely invested at 5 per cent. How many teachers in academic circles could see their way clear to saving that amount in a teaching period of twenty-four years or more on the salary scales now prevailing in American colleges and universities?

The Public Health Service employing a considerable number of medically trained investigators in many respects parallels the situation seen in the navy; while the higher ranking officers are less well paid, the terms of retirement are similar for the body of the service.

BUSINESS ENTERPRISES

The statement is frequently heard that now as never before the ambitious and alert young man is "going into business." The sons of teachers and other professional parents are seeing in the money game something more interesting than they see in the life of the teacher and researcher of the college and university. The term "business" includes many kinds of work, but in all of them the financial gain is the common motive. Not all going into business, however, expect to become wealthy. Many are indeed content with the outlook for a comfortable and ample

income, but value highly the independence or opportunity for self-dependence offered by business.

It was deemed to be a matter of importance for this study to ascertain the rates of pay met with in one great line of business, that of the manufacturer. The scale of pay above the lower grades is considered to be significant, because up this scale the young college man must climb, and one of his great incentives in going into business is the thought that even the president's position may perhaps one day be his. In other words, the scale of opportunity in a business enterprise competes with that of the college or university in the mind of the young man laying his plans for life.

Through the great kindness of the chief executive of a well-known American manufacturing enterprise, I have been able to present here the salary scales of twenty business enterprises, a majority of them dealing with the making and selling of some kind of desired product. These enterprises range in magnitude from one having 400 employees to another commanding the services of over 35,000 persons. One does an annual sales business of three million dollars; another sells products valued at over 150 million dollars. The materials dealt in cover, among others, oil, paper, rubber goods, leather, automobiles, chains, locks, machinery, cotton and life insurance.

Getting the effort of individuals directed and coordinated requires the distribution of responsibility. Such an effective distribution when set in working order constitutes an organization, and reflects the same laws of psychology and of motive whatever may be the product developed. Thus, a university, an army or navy unit, a manufacturing establishment obey the same laws of the human mind and form structures of more or less definitely homologous parts. As responsibility broadens down from the head through the various grades of subordinates, similarities appear in all these types of organization. I believe it would be possible to find the homologue of the university president, dean, professor, instructor, etc., in the organizations here dealt with. However, in order to avoid distracting considerations that might enter were that to be attempted here, I have accepted the positions as ordinarily named in these enterprises and have not attempted to draw a close parallel between manufacturing and academic enterprises.

In order to give an idea of the various sizes of the concerns here dealt with, I have grouped them according to the number of employees on their rolls and the amount of sales made in a year.

TABLE IX

ENTERPRISES GROUPED ACCORDING TO ANNUAL AMOUNT OF SALES

Amount of Sales	Number of Enterprises
Up to $10,000,000	6
$ 10,000,001 to $20,000,000	1
20,000,001 to 30,000,000	2
30,000,001 to 40,000,000	2
40,000,001 to 50,000,000	0
50,000,001 to 60,000,000	0
60,000,001 to 70,000,000	1
70,000,001 to 80,000,000	1
100,000,000	2
160,000,000	1
Three billion dollars	1
Not given	3
Total	20

TABLE X

ENTERPRISES GROUPED ACCORDING TO NUMBER OF EMPLOYEES

Number of employees	Number of enterprises
Up to 1,000	3
1,001 to 2,000	2
2,001 to 3,000	3
3,001 to 4,000	0
4,001 to 5,000	2
5,001 to 6,000	1
6,001 to 7,000	0
7,001 to 8,000	4
8,001 to 9,000	0
9,001 to 10,000	1
15,000	1
38,000	1
Not given	2
Total	20

In the tables that follow are shown the sums received by the various officers so grouped as to present the information in compact form. Range of payment is given and an average sum for the group is usually added.

President. The presidents and other higher officers of these twenty concerns in some cases receive salaries indicated as such, and in some cases bonuses are added to the sums specified as salaries. These bonuses are sometimes fixed sums and, added to the sums known as salaries, form the equivalent of salaries of academic faculty members. In some cases the bonus varies between specified limits.

Vice-president. In a majority of cases, the organization includes from two to as many as nine vice-presidents. These several vice-presidents usually form a graded series in magnitude of salaries. In

TABLE XI

SALARIES OF PRESIDENTS

Salary range	Number of concerns
$ 20,000 to $ 30,000	3
30,001 to 40,000	1
40,001 to 50,000	0
50,001 to 60,000	0
60,001 to 70,000	4
70,001 to 80,000	2
100,000 to 115,000	1
150,000	1
Unknown	8
Total	20
Lowest salary given	$ 20,000
Highest salary given	150,000
Average of known salaries	48,958

the following table the total number of vice-presidents is given, their salary ranges and a weighted average salary.

It will be seen later that in some concerns one of the vice-presidents constitutes the general sales manager, while in others there is a special officer so designated.

TABLE XII

SALARIES (INCLUDING BONUSES) OF VICE-PRESIDENTS

Range of salaries	Number of vice-presidents
$ 8,000 to $10,000	2
10,001 to 20,000	4
20,001 to 30,000	3
30,001 to 40,000	7
40,001 to 50,000	2
25,000 to 30,000	4
30,000 to 33,000	1
30,000 to 60,000	9
35,000 to 40,000	4
36,000 to 40,000	1
40,000 to 45,000	1
Unknown	7
	45
Lowest salary given	$ 8,000
Highest salary given	125,000
Weighted average for vice-presidents	36,135

Treasurer. The treasurer's office sometimes forms the point of attachment for assistant treasurers, controllers and auditors, and salaries of this group of assisting officers are here given in Table XIV as well as those of the treasurers. (Table XIII.)

TABLE XIII

SALARIES (INCLUDING BONUSES) OF TREASURERS

Salary range	Number of treasurers
$ 5,500 to $10,000	2
10,001 to 15,000	1
15,001 to 20,000	4
20,001 to 25,000	0
25,001 to 30,000	2
30,001 to 35,000	3
50,000	1
24,000 to 27,000	1
Unknown	6
	20
Minimum salary	$ 5,500
Maximum salary	50,000
Average salary for treasurers	24,464

TABLE XIV

SALARIES FOR ASSISTANT TREASURERS, AUDITORS AND CONTROLLERS
(No bonuses given)

Salary range	Number of officers
$ 4,500 to $10,000	9
10,001 to 15,000	3
15,001 to 20,000	1
20,001 to 25,000	1
25,001 to 30,000	1
	15
Minimum salary	$ 4,500
Maximum salary	30,000
Average salary paid	11,579

The officers above dealt with form the apical group of these organizations. Under general direction from this group are the main lines of development of these enterprises. One line has to do with the manufacturing processes, plant and machinery, headed by the works manager. The sale of the product is carried on by another suborganization headed by the general sales manager or merchandise manager.

General sales manager. The salaries paid to general sales and mechandise managers are frequently on a sliding scale supplemented by a range of bonuses likewise on a sliding scale. This makes it somewhat difficult to condense the data at hand into a compact table. Hence in cases some assumptions

are necessary that render any summary statement an approximation only. I believe, however, that the chief features here brought out are near enough to the truth to be of value.

The lowest sum mentioned is $7,500 to $8,000; the highest, $41,000. The average minimum rate is $14,071; the average maximum rate of ranges given equals $19,925. The average of definitely fixed salary rates listed is $18,777. A weighted average of money paid to these officers is $19,930 per man. This condition exists because concerns having a large number of sales managers pay higher amounts than those hiring a smaller number of managers. The unweighted average of rates paid gives $17,331. It is believed that the weighted average per man, $19,930, represents a fair norm for this group with extremes much below and much above this sum. The distribution of rates is given in Table XV.

TABLE XV

SALARIES PLUS BONUSES PAID TO GENERAL SALES AND MERCHANDISE MANAGERS

Pay rates	Number of men concerned
$ 7,500 to $10,000	3
10,001 to 15,000	4
15,001 to 20,000	12
20,001 to 25,000	2
10,000 to 21,000	5
15,000 to 25,000	8
Up to 20,000	175
32,000 to 41,000	10
	219
Unknown	3
	222
Minimum rate	$7,500 to $ 8,000
Maximum rate	41,000
Weighted average paid per man	19,930

There is little information at hand concerning assistant general sales managers. In the instances at hand the range of pay runs from $4,900 to $13,000, the weighted average being $7,350. Very likely the duties here concerned are discharged by officers bearing other designations in most cases.

District managers. In the case of district managers, remuneration is still on the basis of salary plus bonus. The salary ranges lie between widely separated extremes, but sliding scales are less often seen. In some cases, a commission bonus introduces a very important and probably highly variable factor. The distribution of salaries is shown in Table XVI.

TABLE XVI

SALARIES PLUS STATED BONUSES PAID TO DISTRICT MANAGERS

Pay rates	Number of men
$ 4,000 to $10,000	109
10,001 to 15,000	6
38,000	1
4,000 to 40,000	700
5,000 to 20,000	40
5,980 to 17,250	not known
Minimum salary stated	$ 4,000
Maximum salary stated	40,000
Weighted average per man	8,708

In attempting to get a sum that might represent a normal salary for this type of position, I have been obliged to work with those cases in which definite sums and definite numbers of men are indicated. In doing this, it has been necessary to neglect 700 men in one concern working on a scale varying from $4,000 to $40,000. In one case, an unstated number of men are receiving from $6,500 to $12,000. In another, forty men receive from $5,000 to $20,000, $10,000 to $12,000 "constituting the average pay for half the group." Thus it is clear that only an approximate average salary can be found.

Salesmen. In the case of salesmen, a fixed salary is sometimes named with a bonus depending in size on the amount of sales made. It is out of the question to learn with any satisfactory degree of approximation what men receive in such cases. However, from the sliding scales given and the fixed figures named, the expectation of salesmen may perhaps be learned within wide limits of variation.

A study involving 1,943 men is not as complete as I wish it were, but data on others are frequently indefinite and I have been obliged to make certain assumptions in order to arrive at a generalized result.

Minimal salaries run as low as $1,800 to $2,000; maximal up to $60,000 in one case. The high figure usually lies between $10,000 and $14,000. A probable normal figure seems to lie at about $6,150.

With this group we seem to reach the bottom rung of the sales department ladder. The minimum sums just mentioned probably represent the pay given to beginners entering the employ of the sales branch of the business.

Works manager. This position concerns itself primarily with the manufacturing side of the enterprise and constitutes the head of this part of the business development, as the sales manager stands at the head of that part of the enterprise that deals with the disposal of the product.

In the following table the salary rate plus bonus is given for works managers.

TABLE XVII

Salary	Number of men
$ 8,500 to $10,000	2
10,001 to 15,000	7
15,001 to 20,000	7
20,001 to 27,300	2
Unknown	4
	22
Minimum salary	$ 8,500
Maximum salary	27,300
Weighted average per man	15,295

Assistant works managers seem not to be usual, but in so far as reported receive a salary varying from $5,600 to $9,100, averaging $7,400.

Division superintendents. The division superintendent is in some cases assistant works manager and in general is subordinate to the works manager in the production branch. Salaries again are often supplemented by bonuses that in many cases exceed the salaries themselves.

The distribution of incomes is given in the following table.

TABLE XVIII

SALARIES, PLUS BONUSES, PAID TO DIVISION SUPERINTENDENTS

Salary range	Number of men
$ 3,000 to $ 5,000	8
5,001 to 10,000	84
10,001 to 15,000	9
3,000 to 6,000	50
4,800 to 13,500	3
9,000 to 13,500	4
	158
Minimum salary	$3,000 to $ 4,500
Maximum salary	13,500
Weighted average per man	5,345

Department heads. Department heads as a rule receive stated salaries and are less concerned with bonuses than those ranking above them.

Foremen. The salaries of foremen seem to be little influenced by bonuses and fall within a rather definite range, between $2,000 and $4,000, with an exceptional man receiving from $5,000 to $6,000. Owing to the lack of data it has been difficult to strike an average paid per man. However, the salary rates are more easily dealt with. The average minimum calculated on the basis of the number of establishments is $2,726; the average maximum, $3,650. A rather risky attempt to get the average salary paid foremen gives $3,139, a figure that is probably not far from the truth.

TABLE XIX

SALARIES, PLUS BONUSES, PAID TO DEPARTMENT HEADS

Range of salaries	Number of men
$2,000 to $ 5,000	225
5,001 to 10,000	6
3,600 to 6,000	17
4,000 to 7,500	30
	278
Minimum salary	$2,000 to $3,500
Maximum salary	7,500
Weighted average per man	4,097

Purchasing agent. The purchasing agent is one of the important members of the staff, sometimes sharing in a bonus based on the evidence of saving in purchasing, I have been told. While extremes of salary are far apart, as a rule the scale for this officer varies less than that of many others. The minimum

TABLE XX

SYNOPTICAL TABLE OF SALARIES IN MANUFACTURING ENTERPRISES

	Minimum	Maximum	Normal
President	$20,000	$150,000	$49,958
Vice-president	8,000	125,000	36,135
Treasurer	5,500	50,000	24,464
Asst. treasurer, Auditor, Controller	4,500	30,000	11,579
General sales manager	$7,500 to 8,000	41,000	19,930
District manager	4,000	40,000	8,708
Salesman	$1,800 to 2,000	10,000 to 14,000	6,150
Works manager	8,500	27,000	15,295
Division superintendent	$3,500 to 4,500	13,500	5,345
Department heads	$2,000 to 3,500	7,500	4,097
Foreman	2,000	4,000 to 5,000	3,139
Purchasing agent	$3,000 to 4,000	25,000	12,437
Asst. purchasing agent	4,000	12,000	5,491
Employment manager	$3,300 to 3,600	13,500	7,330
Office manager	$3,900 to 4,500	13,500	7,676

falls in one or two instances between $3,000 and $4,000, while the maximum rises to $25,000. The average salary paid to twenty purchasing agents was $12,437.

Assistant purchasing agents. The salary of assistants varies from about $4,000 to as high as $12,000 in one case, the average of fifteen salaries being $5,491.

Employment managers. This officer seems not to share in the bonus usually and works at a salary that seems to vary between wide limits. The minimum seems to lie at $3,300 to $3,600, with a maximum of $13,500 seen in one case. The average received by ten employment managers is $7,330.

Office manager. The office manager receives a minimum of $3,900 in one case, the lower range lying between $4,500 and $5,000; the higher range lies between $13,500 and $14,500. The average paid nine such officers is $7,676.

SUMMARY

A comparison of salary scales of trained men shows rather clearly at the present time that

(1) The pay scale of endowed and state universities and agricultural colleges is approximately like that of the commissioned officers of the army and the navy, but lacks the advantage of the retiring pension of three fourths pay. This pension often relieves the military and naval officer of the necessity of saving for old age. The saving required of the academic man to give him an equivalent retiring fund is not practicable at the present salary scale.

(2) It shows that the academic salary scale is appreciably lower than that of the professional and scientific services of the national government at Washington. The retiring allowance of the government employee, though small, and in part contributed by the employee himself, gives him a distinct advantage.

(3) The salaries of all groups above mentioned are very much lower than those paid in manufacturing enterprises to positions above the wage-earners.

In order to make a concrete comparison, I will enumerate the positions that on the average command salaries of $3,000, $6,000 and $9,000 respectively in these different lines of work.

THREE THOUSAND DOLLARS WILL BUY

A. Manufacturing enterprises
- a. Young or unsuccessful salesman
- b. Low-grade department head
- c. Almost the average foreman

B. Universities and colleges
- a. Low-grade associate professor
- b. High average assistant professor

C. U. S. Army
- a. Low pay captain
- b. Young first lieutenant
- c. Sub-average second lieutenant

D. U. S. Navy
- a. Low-rate senior lieutenant
- b. Medium rate ensign

E. U. S. Civil Service
- a. High assistant in professional grade
- b. Low associate in professional grade
- c. High assistant in sub-professional grade

SIX THOUSAND DOLLARS WILL BUY

A. Manufacturing enterprises
- a. Low assistant treasurer
- b. Low district manager
- c. Average salesman
- d. Good average division superintendent
- e. Good average assistant purchasing agent
- f. Low average employment manager
- g. Low average office manager

B. Universities and colleges
- a. Well-paid dean
- b. High professor

C. U. S. Army
- a. Medium colonel
- b. Well-advanced lieutenant colonel
- c. Well-advanced major

D. U. S. Navy
- a. Well-advanced captain
- b. Well-advanced commander
- c. Well-advanced lieutenant commander
- d. Very high senior lieutenant

E. U. S. Civil Service
- a. High average principal in professional grade

NINE THOUSAND DOLLARS WILL BUY

A. Manufacturing enterprises
- a. High average district manager
- b. Low average auditor or controller
- c. High average assistant purchasing agent
- d. Good salesman

B. Universities and colleges
- a. Low average president
- b. High dean
- c. Very exceptional professor

C. U. S. Army
- a. Little less than major general

D. U. S. Navy
- a. Little less than rear admiral (upper half)

E. U. S. Civil Service
- a. Maximum for head of large bureau
- b. Minimum for director of research in a department

DISCUSSION OF PAPERS ON THE ECONOMIC STATUS OF SCIENTIFIC WORKERS

ANY comments which I make are supposed to be in the nature of discussion of the previous papers. The papers which have been read have pointed out in great detail the facts regarding the salaries of university teachers. By implication these papers have said that the salaries were too low. With your permission I should like to confine my discussion to the one point of whether there is a feasible way to raise university salaries.

Some one may respond immediately, "Yes, there is a method, give the universities more money." That, of course, will help temporarily but it can not be a final and satisfactory solution of the difficulty. Under present conditions more money to the universities would lead to more people partially trained for teaching and research who would be seeking positions and it would lead to a continuation of the present pressure bringing about low salaries. We can find no reason for thinking that doing more of the same thing we are doing will lead to a more satisfactory salary situation. It is not more of the same thing that needs to be done; it is a different thing that needs to be done if salaries are to be increased.

Some one else may suggest that we need more agitation, more discussion of higher salaries. We can see no reason to think that agitation will be much more effective in raising salaries than it is in raising the price of wheat. Each farmer in the country might spend an hour a day urging people to pay $2.50 per bushel for wheat, but the talking would have almost no effect in raising the price of wheat. As long as world conditions of supply and demand remain about as they are, people can buy wheat for less than $2.50 per bushel and no amount of talking will persuade them to pay more. As long as present conditions of supply and demand of trained or partially trained university people remain about as they are university authorities can obtain about the present level of ability at about the present salaries and discussion will not lead them to pay a great deal more.

Rather careful study has failed to disclose a case of a normal competitive group where discussion has raised wages. When, due to ignorance, a group has been working for less than its competitive worth discussion has raised wages. Also in some cases of underprivileged and exploited workers discussion has led to certain minimum wages on other than direct economic grounds and thereby has raised wages. It seems doubtful if discussion is able to raise the salaries of professional groups or of skilled trades or even unskilled work unless the previous conditions apply.

We know from a large amount of recent work that an increase of supply leads to a lower price in a long list of manufactured commodities and agricultural products. The Department of Agriculture has shown that an increase of 10 per cent. in the peach crop led to a 7 or 8 per cent. reduction in the price per bushel. A 10 per cent. increase in the number of hogs led to about a 7 per cent. decrease in the price per pound. A 10 per cent. increase in the number of farm hands led to a 7 per cent. decrease in the wages per day. We have the case of a large cotton crop in one year being less valuable than a much smaller crop the year before. We would not insist that the same thing holds true in the same rigid way for university salaries; however, a study involving several hundred thousand public-school teachers lends color to the belief that the same basic facts may control in all such cases. A careful study should be made of the relation of supply of trained or partially trained people to university salaries. At present the evidence of the close relation is so strong that one should hesitate to state that as a long-term policy salaries can be controlled by any other method than by a consideration of supply and demand of trained or partially trained people.

L. D. Edie, professor of finance, University of Chicago, says, "Educated labor does not receive relatively high wages because it is educated but because there is a scarcity of educated workmen."

It is possible that it is necessary to plan supply and demand if university salaries are to be raised to a level to attract the best ability in the country. Some people may say that the number of scientific workers must not be limited. But for the future of science it is much more important that the supply be limited to those who can be placed at adequate salaries than it is to train or partially train large numbers and have many of them working for unsatisfactory salaries. The first policy, planning the number and obtaining adequate salaries, will lead to many of the ablest people going into science; the second policy, training or partially training an excessive number, will lead to inadequate salaries and ultimately will react to keep the ablest people from going into science.

If science wants the highest type of minds it must be willing to plan in order to get them. No time, money or ability could be better spent in America to-day than in working out such plans regarding numbers that adequate salaries would be paid, and they would ultimately lead to a substantial proportion of the ablest young people entering science.

HAROLD F. CLARK

TEACHERS COLLEGE,
COLUMBIA UNIVERSITY

OBITUARY

ALEXANDER ZIWET

(FEBRUARY 8, 1853–NOVEMBER 18, 1928)

A SAGE albeit pessimistic prophet of old time observed that the earth "giveth much mould whereof earthen vessels are made, but little dust that gold cometh of." In the passing of Alexander Ziwet the world has lost—as a scholar and a man—one of its rarest golden products. Yet he leaves a memorial more vivid than any inadequate words chiseled on stone or bronze or recorded on written or printed page, a memorial "graven . . . in the hearts of men" who had the privilege of knowing him as a friend and teacher. A lover of the accumulated wisdom and beauty of the ages, of the aristocrats of achievement in thinking and acting since the beginning of recorded time, he cultivated the mind without loss of interest in the problems of the present, though standing silently aloof from those who count "our life a pastime and our time here a market for gain." A grand seigneur in the realm of the mind, he, nevertheless, felt a warm sympathy for the poor and the oppressed, reserving scorn solely for cheapness and pretense. No one better realized Huxley's ideal of education: "the instruction of the intellect in the laws of nature . . . not only things and their forces, but men and their ways; and the fashioning of the affections and the will into an earnest and loving desire to move in harmony with those laws." Studiously he sought "the wisdom we have inherited." Feeling that he did "not know the world" until he knew "the men who had possessed it and tried its wares" before he was "given his brief run upon it," he steeped himself in the lore of bygone generations. However, "he read not to contradict and confute, nor to believe and take for granted, nor to find talk and discourse, but to weigh and consider." More than most, although too modest to be consciously aware of it, he lived up to Carlyle's maxim that "no man can hope to do anything worth doing and that has the temper of eternity in it without strenuous effort."

While the life of a scholar is prevailingly one of mental and spiritual adventure, the early career of Alexander Ziwet was more varied than falls to the lot of the majority. He was born in Breslau, Germany, of a Polish father and a German mother, both of aristocratic lineage. Indeed, through his paternal ancestry he was connected with noble historic names. Beginning his education under private tutors on his father's estate, at the age of twelve he was sent to the gymnasium of Glogau in German Silesia, where he graduated in 1870. His father having died the previous year, he joined his mother and sisters who had removed to Warsaw. There he learned Russian and perfected Polish and entered the university. In 1873 he transferred to the University of Moscow, where he remained until 1874, when he departed to study engineering in Germany. Owing to reverses in the family fortunes consequent upon his father's death he was thrown largely upon his own resources and seems to have worked for a time in an architect's office. Later he entered the Polytechnic School at Karlsruhe, from which he was graduated in 1880 with the degree of Civil Engineer. Meanwhile he had served the required year in the army and had passed his examination for a commission in the reserve artillery corps.

Influenced to some degree, at least, by the advice of his friend and fellow-student, Mr. Arthur E. Keifer, Alexander Ziwet came to Detroit in the autumn of 1880, and after two years in the Lake Survey and upwards of five years in the computing division of the U. S. Coast and Geodetic Survey, he was appointed instructor in mathematics at the University of Michigan in 1888. He worked his way up slowly through the various grades until he became a professor of full rank in 1905, a recognition long overdue. This was not because of failure to appreciate his vast and accurate learning or his sympathetic and stimulating teaching. Advancement was far from rapid in those days, and a man of his modest and delicate instincts was not one to push his own claims. For several years he was head of the department of mathematics, and for a briefer period head of the department of modern languages in the college of engineering. He had offered his resignation more than once before it was accepted in 1925, when he became professor emeritus. In 1927 the university very fittingly conferred upon him the honorary degree of doctor of science.

Prominently connected with the development of mathematics in the United States, he was a member of the editorial board of the *Bulletin* from 1892 to 1920, and served as vice-president of the American Mathematical Society during 1903. He was vice-president and chairman of Section A of the American Association for the Advancement of Science during 1905. His retiring address on "The Relation of Mechanics to Physics" was published in SCIENCE, on January 12, 1906. He was also a member of the executive council which organized the Mathematical Association of America in 1916. To his colleagues and to serious students Professor Ziwet gave most generously of his time and thought. He was one of the founders of the University of Michigan Mathe-

matical Club, and was exceedingly active in promoting the general scholarly interests of the university, being president as well as one of the influential members of the University of Michigan Research Club. In addition to various translations his published work was considerable and was characterized by wide knowledge and individual interpretation.

As he once casually told me he was brought up a devout Roman Catholic. Though he subsequently broke off all association with the church he retained a sentiment which led him on occasion to rebuke, in his somewhat excitable manner, any one who, from ignorance or prejudice, spoke disparagingly of the ancient institution. This sentiment may have been accentuated by the fact that a favorite sister, two years his senior, became a nun. Until her death about four years ago she was prominent in educational work in Prague. His service in the German army developed in him an enduring hatred of militarism—a hatred which extended to all forms of despotic government. During the World War he cherished a real if somewhat reticent sympathy for the German and Russian people: nevertheless he gave freely to the Red Cross and even, I believe, to the Y. M. C. A.

His command of languages was exceptional. Not only was he well grounded in Greek and Latin but he had some acquaintance, at least, with Sanskrit and Hebrew. Seemingly he spoke German, French, English, Polish and even Russian with equal fluency; in addition, he read Italian and Spanish with ease. Indeed, when any in his immediate circle had difficulties with a letter in a foreign tongue it was to him that they naturally turned; moreover, he was an unfailing resource for the pronunciation of unusual European names. His instinct for helpfulness was extreme. When questions came up in general conversations in which he happened to be present, on the rare occasions when he was unable to throw light upon an obscure point, he would within a short interval proffer the requisite information graciously though unobtrusively. The last instance I recall had to do with the Lemnians in art. He read widely not only in his own field of mathematics and mechanics but in history, particularly in memoirs and biography. Long before he gave his large and carefully selected technical library to the university—it is said to have totaled upwards of 5,000 volumes including 400 works in mechanics, some of them exceedingly rare—it had become his custom to hand over to the library all sorts of books of a general character after he had read them. His literary appetite was insatiable. The writer recollects calling on him one hot summer evening to find him deep in Roger Bacon's "Opus Majus." For his years of devoted service on the library committee the university owes him a further incalculable debt.

He was one of the founders of the Apostles Club (1900), a name derived from a chance comment of the late Sarah Caswell Angell anent the original number of twelve. Although a generation the senior of the other oldest members and although he usually had little to say, he was such a courteous and interested listener that he constituted a most harmonious element in an organization composed largely of younger bachelors on the faculty. Until recent years on request he would linger a bit for a hand of skat or a rubber of bridge, until failing health obliged him to discontinue the practice. He would start off shortly after meals in his abrupt fashion, though always glad of company on his walk to his rooms. Sometimes he talked freely; at other times he trudged on in friendly silence. He not only contributed generously to the customary Apostolic wedding gift but also gave a beautiful individual present; yet to my knowledge he never attended a wedding. His private charities were as unostentatious as they were extensive, and among his effects were found various notes, aggregating a not inconsiderable sum, from borrowers who he must have realized would very likely never repay him.

He was exceedingly fond of young children, and many parents will recall his frequent Sunday calls, his jolly rompings with their sons and daughters when they were small. In spite of his intense application to his studies he was for many years a faithful attendant at concerts and took tickets long after he ceased regularly to attend. At one period he made an occasional trip abroad. But his travels grew less and less frequent. At length if he journeyed to Chicago or even to New Orleans for a meeting he would customarily remain for no more than a single day's session. Until middle life he was a skater of exceptional skill, and for a while rode horseback with a little group of colleagues. He even tried golf, though without conspicuous success.

Advancing years and failing eyesight led to the inevitable relinquishment of all diversions, until his only recreations were walking to and from his meals at the Apostles Club and infrequent Sunday afternoon calls on a few old friends, preferably those with young children. During his last years his sight was so defective that he could scarcely recognize a familiar face a few feet away, and he could read only with the help of the strongest magnifying glass. While woefully hampered in his sole remaining means of occupying his leisure, he maintained his serenity with stoic courage, and followed with unflagging

interest the latest developments in his subject, thanks to the devoted care of Miss Josephine Pattison, at whose home his last years were spent. One of the noble living he has now joined the great society of the noble dead. "Wisdom raineth down skill and knowledge of understanding, and exalteth to honor them that hold her fast." None could have been held in higher honor by those who knew his qualities, and so we leave him.

ARTHUR LYON CROSS,
Chairman of Senate Memorial Committee
UNIVERSITY OF MICHIGAN

SCIENTIFIC EVENTS

INDUSTRIAL STANDARDIZATION

A COOPERATIVE agreement between the American Standards Association and the U. S. Bureau of Standards, which will encourage national standardization activities in all industries, was ratified on July 9 by Dr. George K. Burgess, director of the bureau, and by the board of directors of the American Standards Association at the first meeting of the board.

The invitation extended to the American Standards Association to join with the national standardizing bodies of fourteen European countries in the International Standards Association, which has its headquarters at Baden, Switzerland, was considered. It was decided, however, that this matter should be held over for consideration at the next meeting of the board, to permit further study of the methods by which the American Standards Association could cooperate with the foreign bodies.

It was also decided to launch an extensive national campaign to finance industrial standardization activities on a basis merited by the tremendous savings which these activities are securing for American industry. A finance committee, consisting of Bancroft Gherardi, *chairman*, Quincy Bent and Howard Coonley, was appointed to head this effort.

The meeting was the first held by the board since its appointment, which followed the recent reorganization of the association. Its members are: W. J. Serrill, president of the American Standards Association, who is also chairman; Cloyd M. Chapman, vice-president of the American Standards Association; C. E. Skinner, past-president of the American Standards Association; Quincy Bent, vice-president of the Bethlehem Steel Company; Dr. George K. Burgess, director of the Bureau of Standards; C. L. Collens, president of the Reliance Electric and Engineering Company; Howard Coonley, president of the Walworth Company; L. A. Downs, president of the Illinois Central Railroad; Bancroft Gherardi, vice-president of the American Telephone and Telegraph Company; F. E. Moskovics, president of the Improved Products Corporation; M. S. Sloan, president of the New York Edison and affiliated companies; R. J. Sullivan, vice-president of the Travelers Insurance Company.

Under the terms of the agreement with the Bureau of Standards, the primary effort of the bureau will be to serve those industrial groups which have no satisfactory standardization facilities of their own. It plans to help these groups to formulate temporary standards designed to meet immediate requirements. The American Standards Association will work primarily with those bodies having standardization facilities and will bring together such groups for the formulation of "American Standards," which represent a true national consensus of approval. Where feasible, temporary standards prepared with the aid of the Bureau of Standards will also be brought before the American Standards Association for advancement to the rank of "American Standards."

The American Standards Association is a national federation of forty government, technical and trade associations and includes the U. S. Department of Commerce, of which the Bureau of Standards is a division, in its membership.

RETIRING ALLOWANCES OF HARVARD UNIVERSITY

THOSE 162 officers of professorial rank in Harvard University whose pensions from the Carnegie Foundation were recently reduced and twenty-four other officers of similar rank who are entitled to university pensions are offered the chance to benefit by a new plan voted by the Harvard Corporation for annuities on retirement.

The vote of the corporation is in line with the Harvard pension system already in operation, but it contains the added feature of provision for the widow of a professor at a rate equal to half the annuity paid to him during his lifetime. The plan is optional. The date for instituting the plan is September 1, 1929.

On May 1, 1929, the Carnegie Foundation announced a reduction in the amount of the annuities to be paid in the future by the Carnegie Foundation. For those becoming 65 years old in 1932 and thereafter, a maximum annuity of $1,000 was allowed at the age of seventy. Subsequently the trustees of the Carnegie Corporation of New York voted to increase by the amount of $500 the annuity to all pensionables who reach the age of sixty-five in 1931 or thereafter; the annuity provided was to be for the life of the annuitant only, unless the annuitant preferred to receive a correspondingly smaller annuity during his lifetime with provision for his widow should she survive him.

In view of this reduction in the amount of the annuities to be received from the Carnegie Foundation, the corporation voted the present plan in order to assure the officers of the university an annuity upon reaching the age of retirement and to provide for the widows of such officers.

Among the provisions of the plan several are outstanding and worthy of special mention. The first is that each officer participating in the plan shall pay each year a sum equal to five per cent. of the salary voted to him, and when this is done the university shall place in the retiring fund to his credit a like sum. This means that a sum equal to ten per cent. of the officer's salary will be paid in the sinking fund for him each year. If any participant ceases to be in the employ of the university prior to retirement for any reason other than his death, the university will pay him the amount of his accumulated credits in the retiring fund.

Each annuity paid by the Harvard Corporation under the plan will include any pension contributed for the annuitant's benefit by the Carnegie Foundation and the Carnegie Corporation. Also the amount standing to the annuitant's credit in the retiring fund will be used to aid in providing the annuity.

To each officer who participates in the plan the corporation will pay after retirement during his lifetime an annuity equal to one half the officer's average salary for five years previous to retirement; and if the officer dies after retirement leaving a widow, the corporation will pay to his widow during her lifetime an annuity equal to one half the amount of the annuity previously payable to the officer. With certain exceptions, not numerous, the maximum annuity under this plan to any officer of the university will be $4,000; and the maximum annuity to any widow will be one half of this amount, or $2,000.

THE NEUROLOGICAL INSTITUTE OF NEW YORK CITY

THE Neurological Institute of New York City is planning to make an elaborate survey of the cause and cure of mental and nervous disorders and their relation to crime.

Fifty-nine leading specialists in the neurological field already have been chosen to conduct the survey along 65 different avenues of investigation, covering crime, behaviorism, modern social problems, delinquency, insanity, epilepsy, sleeping sickness and other mental and nervous diseases. Their work will be coordinated and directed by a committee of three—Dr. Frederick Tilney, *chairman;* Dr. Charles Elsberg, and Dr. Walter Timme.

Robert Thorne, president of the Neurological Institute, announced the project following a meeting of the joint committee of the medical board and trustees at which it was disclosed that an anonymous donor had given $150,000 to erase the final payment on the new building at the Medical Center, Broadway and 168th Street.

During the building fund campaign the Neurological Institute officials promised that, after they had acquired a thoroughly equipped establishment at the Medical Center, they would undertake a program of research and would conduct a special investigation into crime and delinquency which would be an aggressive attack on the advance of lawlessness. This is what they now propose to do.

In addition to the individual research program Dr. Tilney, Dr. Timme and Dr. Edwin G. Zabriskie will make a special study of the organic brain changes in early life which lead to maladjustments, delinquency and criminal tendencies.

Dr. Tilney will supervise the section covering prenatal brain disorders. Dr. Timme will direct research on ductless gland disorders and their relation to delinquency and criminal tendencies. Dr. Zabriskie will conduct the investigation into the early post-natal development of the child in its relation to maladjustment and anti-social reactions.

The publication of a scientific journal by the Neurological Institute to disseminate the results of the investigation also was approved at the meeting of the joint committee of the medical board and trustees. This journal will be distributed among scientific workers, lawyers, social service bodies and all those who are working in the field of crime, delinquency and social adjustment.

A joint committee has been appointed to raise the $2,000,000 necessary to endow the research program.

THE MEDICAL CENTER IN RICHMOND, VIRGINIA

ANNOUNCEMENT has been made of plans for the development of the medical center in Richmond at the Medical College of Virginia by Dr. W. T. Sanger, president of the institution. The work will likely cover a number of years.

The first unit of the new center, a building for the college school of nursing costing approximately $300,000 for construction, equipment and site, has been completed. The other units will go up as fast as funds, which are being sought in different directions, are available. Most of the ground to be used has already been acquired.

The buildings projected are:

1. A library to be constructed in association with the library of the Richmond Academy of Medicine—cost approximately $125,000.

2. A teaching unit to house the outpatient department and laboratories for the teaching of chemistry, bacteriology and pathology—cost approximately $750,000.

3. A nurses' dormitory for the St. Philip Hospital school of nursing, an institution maintained by the college for Negro girls—cost approximately $150,000.

4. A building for clinical dentistry—cost approximately $400,000.

5. A general hospital for white patients to be built in association with the outpatient department and teaching laboratories—cost $1,000,000 or more.

6. A gymnasium, auditorium and recreational center—cost undetermined.

When this plan is carried through then it is hoped to provide dormitories for students in the schools of medicine, dentistry and pharmacy.

W. T. SANGER,
President

JULY 12, 1929

THE FIRST INTERNATIONAL CONGRESS ON MENTAL HYGIENE

PROGRESS is being made in the organization of The First International Congress on Mental Hygiene, to be held in Washington, D. C., May 5–10, 1930. Educators, psychiatrists, other physicians, public officials, social workers, industrialists and many others from all over the world are expected to be present when the congress convenes.

Herbert C. Hoover has honored the congress by accepting the position of honorary president. Already twenty-six countries are represented on the Committee on Organization, of which Dr. Arthur H. Ruggles, of Providence, R. I., is chairman. Dr. William A. White, of Washington, D. C., is president of the congress, and Clifford W. Beers is secretary-general. The congress is being sponsored by mental hygiene and related organizations in many countries.

Questions to be discussed at the congress will include the relations of mental hygiene to law, to hospitals, to education, industry, social work, delinquency, parenthood and community problems. A world-wide view of mental hygiene progress will be given. The subject will be discussed also in specific application to the maladjustment problems of individuals, special attention being probably given to childhood, adolescence and later youth. It is the contention of those promoting the congress that mental hygiene has to do with the conservation of mental health in general, not merely with nervous and mental diseases. The point of view of clinical diagnosis and treatment will be considered, as well as that of administration of institutions and agencies.

The basic expenses of the congress are being underwritten by the recently organized American Foundation for Mental Hygiene. Opportunity will be afforded for acquaintance among delegates of the various countries, and translations, together with other conveniences, will facilitate comprehension of all that may be said in unfamiliar languages. Administrative headquarters have been opened at 370 Seventh Avenue, New York City, where John R. Shillady, administrative secretary, is in charge. A membership fee of $5 (including the *Proceedings*) has been fixed.

THE MAYO FOUNDATION CHAPTER OF SIGMA XI

THE Mayo Foundation Chapter of Sigma Xi held seven meetings during the season 1928–1929. The speakers and the subjects presented were:

October 23, 1928.
Dr. Clifton Tuttle, research laboratories, Eastman Kodak Company, "Recent Developments in Color Photography."

November 20, 1928.
Dr. Curt P. Richter, psycho-biological laboratory, the Johns Hopkins University, "Experimental Studies on Sleep and Similar Conditions."

December 11, 1928.
Dr. Edwin B. Frost, director of the Yerkes Observatory, Chicago, "The System of the Stars."

January 29, 1929.
Professor Edwin B. Hart, University of Wisconsin, "Iron in Nutrition."

February 15, 1929.
Dr. H. T. Stetson, professor of astronomy, Harvard University, "Sun-spots and Radio."

March 12, 1929.
Dr. Harvey Fletcher, director of acoustical experimentation, Bell Telephone Company, "How and What We Hear."

May 20, 1929.
Presidential address by Dr. Charles Sheard, Mayo Clinic, "Our Weather, Inside and Out."

The officers elected for next year were:

H. E. Robertson, *President.*
Walter Boothby, *Vice-president.*
A. E. Osterberg, *Secretary-Treasurer.*

SCIENTIFIC NOTES AND NEWS

DR. ELMER D. MERRILL, professor of agriculture, dean of the college of agriculture, director of the experiment station and of the botanical garden of the University of California, has been appointed director of the New York Botanical Garden, to succeed Dr. N. L. Britton, who is retiring after reaching the age of seventy years.

AT the Portland meeting of the American Medical Association, Dr. William Gerry Morgan, of Washington, D. C., was elected president to succeed Dr. W. S. Thayer, of Baltimore. Dr. Ernest A. Sommer, of Portland, was elected vice-president. Dr. Olin West, of Chicago, was reelected secretary; Dr. Austin A. Hayden, of Chicago, treasurer, and Dr. F. C. Warns-

huis, of Grand Rapids, Michigan, speaker of the house of delegates. Dr. Warnshuis is completing his eighth term as speaker. Others elected were: Dr. A. E. Bulson, of Fort Wayne, Indiana, vice-speaker of the house; Dr. Chester Brown, of Danbury, Connecticut, and Dr. Allen H. Bunce, of Atlanta, Georgia, trustees for five years. Detroit was selected as the place of meeting in 1930.

PROFESSOR IRVING P. CHURCH, emeritus professor of applied mechanics and hydraulics at Cornell University, has been awarded the Benjamin G. Lamme gold medal "for accomplishment in technical teaching or actual advancement of the art of technical training" by the Society for the Promotion of Engineering Education.

DR. CARL STUMPF, professor of philosophy at Berlin, has been awarded the Prussian order of merit in science and art. Professor Stumpf, known for his work on hearing and music, is the only psychologist who is a foreign member of the National Academy of Sciences.

THE Prince of Monaco prize of the Paris Academy of Medicine has been awarded to Professor Borrel, at present director of the institute of hygiene in Strasbourg and formerly one of the collaborators of the Institut Pasteur in Paris, for his researches on the etiology of cancer.

THE Wisconsin Chapter of Sigma Xi announces the election of the following officers for the year 1929–30: Professor H. A. Schuette, *president;* Dr. W. D. Stovall, *vice-president;* Professor R. C. Williamson, *secretary,* and H. R. Aldrich, *treasurer.* Professor W. H. Peterson was elected to the board of nominators.

PROFESSOR J. W. GREGORY, having attained the age of sixty-five years during the past session, has resigned the chair of geology in the University of Glasgow which he has held since 1904.

CHARLES S. WILSON, of Hall, formerly New York state commissioner of agriculture and professor in the state agricultural college at Cornell University, has been appointed a member of the Federal Farm Board.

DR. J. E. WALLACE WALLIN, professor of clinical psychology at Miami University, has been appointed to head a new department in the public-school system of Baltimore, which will supervise studies and other school work of physically and mentally handicapped children.

DR. HARRY S. LADD, of the department of geology of the University of Virginia, has been appointed paleontologist with the Venezuela Gulf Oil Company and will leave for Maracaibo in September.

JOHN PATTERSON has been appointed director of the Meteorological Service of Canada, succeeding Sir Frederic Stupart, who retired at the end of June, after serving for fifty-seven years.

DR. W. T. H. WILLIAMSON, senior assistant lecturer in agricultural chemistry at the Edinburgh and East of Scotland College of Agriculture, has been appointed director of the chemical section of the Egyptian ministry of agriculture, to succeed W. S. Gray, who died last year.

MAJOR DANIEL I. SULTAN, who is now on duty with the River and Harbor Board in the office of the chief of army engineers, has been placed in charge of the investigation and survey in Nicaragua of the proposed new transoceanic canal route, as authorized by the Edge resolution adopted by the Senate last winter.

DR. ROLLIN T. CHAMBERLIN, of the University of Chicago, is attending the International Geological Congress in South Africa as one of the representatives of the National Academy of Sciences and the Geological Society of America.

A COMPREHENSIVE study of European museum methods is to be made by Stephen C. Simms, director of Field Museum of Natural History, who sailed on July 7 from New York for England. Mr. Simms will visit the principal museums of Great Britain and the continent. He will be accompanied on the trip by Joseph N. Field, son of Stanley Field, president of the museum.

DR. J. L. COLLINS, assistant professor of genetics in the University of California, has sailed from San Francisco for Honolulu, where he will work for a year at the Hawaiian Pineapple Experiment Station in connection with pineapple breeding investigations.

DR. KARL LARK HOROVITZ, professor of physics and director of the physical laboratory at Purdue University, sailed on the *Deutschland* on July 6, for an extensive inspection tour of the principal European laboratories where glass research work is being conducted. He will also visit the largest of the glass manufacturing companies. This inspection trip will take him into England, Holland, Germany, France, Austria, Switzerland and Czechoslovakia. G. Stanley Meikle, director of industrial research relations, who secured the necessary endowments and arranged for the European tour, announces that this is but the beginning of extensive scientific research work in glass to be conducted at Purdue University.

WE learn from the *Journal* of the American Medical Association that Dr. E. Blanco-Acevedo, of the faculty of medicine of the University of Montevideo, is visiting medical centers in the United States to gather plans for a medical center to be erected in

Montevideo, of which he will be the president and on which it is planned to expend $10,000,000.

PRIOR to the opening of the meeting of the American Chemical Society at the University of Minnesota, September 9 to 13, a symposium on chemical kinetics will be conducted as an integral part of the second summer session, July 29 to August 31. Dr. M. Polanyi, of the Kaiser Wilhelm Institute, Berlin, and Professor Hugh S. Taylor, of Princeton, together with Dr. S. C. Lind, head of the Minnesota School of Chemistry, and others, will offer courses and laboratory demonstrations. Professors M. von Frey, of the University of Würzburg, and G. V. von Anrep, of Cambridge University, will be the guest teachers during the symposium on biochemistry and physiology. The directing committee from Minnesota, all of whom will take part, is composed of Professors Ross A. Gortner, J. F. McClendon, F. H. Scott and Dean E. P. Lyon, of the Medical School.

DR. WILLIAM J. GIES, professor of biological chemistry at Columbia University, delivered addresses on various aspects of dental education, at meetings of the Kings County Dental Society in Brooklyn, February 14; the Cincinnati Academy of Medicine and the Cincinnati Dental Society in joint session, March 11; the American Association of Dental Schools, Chicago, March 25; the Kentucky State Dental Association, Louisville, April 9, and the Michigan State Dental Society in Detroit, June 18 and 19.

DR. ARTHUR S. PEARSE, of Duke University, is spending a year in Japan and will give lectures on biology in the University of Tokyo. In a recent note in SCIENCE, through a confusion of names, it was reported that Dr. Richard M. Pearce would give these lectures.

DR. MAURICE FISHBERG will address the annual meeting of the British Medical Association on July 24 on "Apical and Subapical Tuberculosis."

DR. ARTHUR D. LITTLE, president of Arthur D. Little, Inc., the Cambridge, Massachusetts, chemists and engineers, delivered his presidential address before the Society of Chemical Industry (London) at Manchester, England, on July 9. His subject was "Science and Labor." He called attention to the opportunities for employment created by scientific discovery, offsetting labor displacement by improved manufacturing practice, new industrial processes and invention. During his stay in England, Dr. Little will receive the honorary degree of doctor of science from the University of Manchester and honorary associateship in the Manchester College of Technology. He expects to return to the United States late in August.

THE U. S. Civil Service Commission announces an examination for the position of mechanical engineer (mine equipment) at a salary of $3,800 a year, applications for which must be on file not later than August 14. The examination is to fill a vacancy in the U. S. Bureau of Mines, for duty at Pittsburgh, Pennsylvania, and vacancies occurring in positions requiring similar qualifications for duty in Washington, D. C., or in the field.

AN International Summer School of Geology and Natural Resources, under the auspices of Princeton University, will this summer study the principal geological formations of England, Scotland and Wales. The American party will be the guests of British geologists, and especially of Professor Owen Thomas Jones, head of the department of geology of the University of Manchester, and E. B. Bailey, of the Geological Survey of Scotland. The party includes: Dr. E. O. Ulrich, U. S. Geological Survey, senior paleontologist, U. S. National Museum, specialist in stratigraphy of the Lower Paleozoic; Dr. T. L. Tanton, Geological Survey of Canada, specialist in pre-Cambrian geology; Professor R. M. Field, department of geology of Princeton University, director of the International Summer School of Geology and Natural Resources, specialist in paleo-oceanography and sedimentation; Professor C. E. Gordon, head of the department of geology in the Massachusetts Agricultural College; Professor T. H. Clark, of the department of geology of McGill University, Lower Paleozoic stratigraphy; L. L. Lee, State of New Jersey Agricultural Experiment Station; Henry Jeffers, Walker-Gordon Company, specialist in grassland management; R. F. Norris, Princeton, '28; J. S. Vhay, Princeton, '29, and W. J. Newell, Princeton, '29.

ACCORDING to recent information received by the American Society for Cultural Relations with Russia from Professor Yarilov, secretary of the Russian committee, the Fourth International Soil Congress will take place from June 1 to 11, 1930, partly in Moscow and partly in Leningrad. From June 11 to 27 there will be the main excursion, including a trip down the Volga, Caucasus and the Ukraine. Special excursions will be arranged for those interested in visiting the Crimea, Siberia and Central Asia. Participation is open to all members of the International Society of Soil Science. The program of the congress embraces not only soil science and agronomy, but also geography, geology, climatology, culture of technical crops, road building, etc. The American Society for Cultural Relations with Russia is organizing the delegation as it has other delegations. To assist it a com-

mittee has been appointed including Dr. Lipman, Dr. McCall, Professor Morgan, Mr. Pincus and others. A general committee will be appointed of representatives from every state agricultural college or station. Further information on program, cost of tours and other details will be forthcoming soon.

A SPECIAL Sugar-Cane Bagasse Utilization Committee has been appointed to make a coordinated study for the U. S. Department of Agriculture of the possibilities there may be in the economic utilization of the very greatly increased volume of bagasse, the by-product of sugar cane as it comes crushed from the mill, now resulting from the successful cropping of the new disease-resistant varieties of sugar cane which have been introduced into Louisiana in recent years. The personnel of the committee is: Dr. H. G. Knight, chief of the bureau of chemistry and soils, *chairman;* Dr. Thomas H. MacDonald, chief of the bureau of public roads; Dr. W. A. Taylor, chief of the bureau of plant industry; H. S. Fairbank, chief of the division of information, and S. H. McCrory, chief of the division of agricultural engineering, bureau of public roads; Dr. W. W. Skinner, assistant chief of the chemical and technological research unit, and Dr. F. P. Veitch, in charge of the industrial farm products division, bureau of chemistry and soils, and Dr. E. W. Brandes, pathologist in charge of the office of sugar plants, bureau of plant industry.

THE Rosenwald Industrial Museum of Chicago is henceforth to be known as the Museum of Science and Industry. The change was made at Mr. Rosenwald's insistence and over the protest of the board of trustees.

THE Carnegie Museum has acquired the collection of *Hesperioidea* formed by Professor A. W. Lindsey, including the microscopic slides, which he employed in the preparation of his various papers upon this group of butterflies. Professor Lindsay has been a most careful and accurate student of the group represented in this collection, and its addition to the otherwise enormous collection in the possession of Dr. Holland and the Carnegie Museum will add greatly to the value of the collection of Hesperids in the Pittsburgh institution.

THE assistant secretary of war has approved the application made by the director of Mt. Wilson Observatory, Pasadena, Calif., on behalf of Dr. A. A. Michelson, of the University of Chicago, for permission to utilize a small portion of Ross Field, Arcadia, Calif., for his investigation on the determination of the velocity of light. Dr. Michelson's experiment involves the use of a straight path about one half mile long, along which the light is sent by mirrors placed on small piers at each end.

The Experiment Station Record reports that the Hannah Dairy Research Institute, Scotland, has recently been established to deal with problems of the milk industry, especially milk production, physiology of milk secretion, the quality of milk and the disposal of milk and its products. The establishment of a dairy research institute for Scotland has been under consideration for some time. During the past year a gift by J. M. Hannah, of the estate of Auchincruive in Ayrshire, for the joint purposes of enabling the dairy school and other departments of the West of Scotland Agricultural College to move from Kilmarnock to a more suitable site and of providing accommodation for the proposed institute, has enabled the plan to go forward. Pending the erection of the necessary buildings, the institute has its temporary headquarters in the Physiological Institute of the University of Glasgow. The institute has been constituted the national institute for dairying in Scotland, and the greater part of its cost of maintenance is accordingly borne from the development fund. It is administered by a joint committee of management, consisting of representatives of the University of Glasgow, the West of Scotland Agricultural College and the Department of Agriculture for Scotland, with Sir Donald MacAlister as chairman. E. P. Cathcart has been appointed interim director, and Dr. Norman C. Wright, who has held a Commonwealth Fund fellowship in the United States for the past two years, has been appointed physiologist.

THE annual statistical review of the British registrar-general has, according to a correspondent of the *Journal* of the American Medical Association, been issued. He states that "with a continuation of present conditions the future growth of population will tend to be at an ever-diminishing rate up to the stage at which births and deaths are equal, the latter thereafter gaining the ascendency, with a consequent decline in population." It is pointed out that "the population as a whole is gradually getting older and will continue to do so for many years to come, owing to the heavy falls which have occurred in both fertility and mortality during the past half century." In 1927 there were 484,609 deaths, 246,606 males and 238,003 females, the death rate of 12.3 per thousand being the highest since 1922. The total population, June 30, 1927, was estimated at 39,290,000 persons, 18,804,000 males and 20,486,000 females, or 1,403,000 over the 1921 census, so that the population had grown at the rate of 3.7 per cent. during the six years. Live births totaled 654,172, or 16.6 per thousand, this being 40,391 less than in 1926, or the lowest on record. The deaths ascribed to cancer during 1927 numbered 54,078, 25,048 males and 29,030 females. For both sexes these numbers are the highest yet recorded.

UNIVERSITY AND EDUCATIONAL NOTES

THE corner-stone of the new Eckhart Hall on the main quadrangle of the University of Chicago, which will house the laboratories of Professor A. A. Michelson and Professor Arthur H. Compton, was laid on July 12 by Bernard A. Eckhart, the donor of the building. Three generations of Eckharts assisted in the ceremony, the donor, his son, Percy B. Eckhart, an alumnus of the university, and his granddaughter, Marion West Eckhart, a junior. Professor Gilbert A. Bliss, acting head of the department of mathematics, which with the department of physics and astronomy will occupy the new structure, and Professor Henry Gordon Gale, dean of the graduate school of science, were among the speakers.

DR. PIERRE A. FISH, a member of the faculty of Cornell University since 1890, when he became an instructor in the department of physiology and neurology, has been appointed dean of the college of veterinary medicine, succeeding Dean Veranus A. Moore, who retires this year.

DR. JEAN R. OLIVER, professor of pathology in the Stanford University Medical School, San Francisco, has been appointed professor of pathology at the Long Island College Hospital, Brooklyn, to succeed Dr. Archibald Murray.

DR. CHARLES L. MIX has resigned as professor and head of the department of medicine, Loyola University School of Medicine, and has been appointed professor emeritus. He will be succeeded by Dr. Italo F. Volini.

AT the College of the City of Detroit, Dr. K. W. Folley, of Trinity College, and Dr. D. C. Morrow, of Northwestern University, have been appointed instructors in mathematics.

DR. W. GARSTANG, professor of zoology at the University of Leeds, England, has been appointed provice-chancellor.

DR. LEWIS F. RICHARDSON, in charge of the department of physics of the Westminster Training College, London, has been appointed principal of Paisley Technical College.

M. L'ABBÉ BREUIL has been elected professor of prehistory in the Collège de France to succeed the late M. Théodor Reinach.

DISCUSSION

BABYLONIAN MATHEMATICS

WITHIN the past twelve years our knowledge of Egyptian and Babylonian mathematics has been considerably extended and it has been surmised that in the near future we may be even better acquainted with Babylonian than with Egyptian mathematics.

Among a number of documents which contribute to the body of known facts regarding Egyptian mathematics two are of outstanding importance: the Rhind mathematical papyrus of about 1650 B. C., a copy of an older document, and the Golenishchev mathematical papyrus dating from about 1850 B. C.; also, probably, a copy of a document dating back earlier, perhaps to 1900 or 2000 B. C.

Of the Rhind papyrus, which is in the British Museum, except for certain fragments in the New York Historical Society, a notable new edition was brought out in 1923 by Professor T. Eric Peet, of the University of Liverpool. A sumptuous two-volume edition by Chancellor Chace, of Brown University, is in the press. Peet's work has inspired many publications, of which the outstanding longer ones are Otto Neugebauer's in 1926 and O. Gillain's volume in 1927. As far back as 1894 it was generally known that Golenishchev, now professor of Egyptian philology at the Egyptian University in Cairo, had a mathematical papyrus, but it was not till Turaev's article in 1917 that we learned anything about this papyrus which had then become the property of the Museum of Fine Arts in Moscow. Tsinserling's article in 1925 gave us still more information. A reproduction of the papyrus with hieroglyphic transcription, German translations and commentary is about to be published by Professor V. V. Struve, of the Hermitage Museum of Leningrad. In 1917 we learned the very extraordinary fact that the Golenishchev mathematical papyrus seemed to prove that the Egyptian of 1850 B. C. knew the equivalent of the formula for the volume of the frustum of a square pyramid. Professor Struve discovered in 1928 that the papyrus contains another geometrical result of an even more extraordinary nature (in spite of what Turaev and Peet have stated to the contrary), indicating a stage of development of geometry among Egyptians undreamt of by scholars a score of years ago.

Until recently comparatively little has been known about Babylonian mathematics. One of the chief sources of information has been Hilprecht's "Mathematical, Metrological and Chronological Tablets of the Temple Library of Nippur," published by the University of Pennsylvania in 1906. He here describes fifty tablets dating from the period 1350 to 2200 B. C. C. J. Gadd's article in *Revue d'Assyrio-*

logie, 1922, discussing a large fragment in the British Museum, was an important addition to what was known of Babylonian geometry about 2000 B. C. Articles by Weidner, Zimmern and Ungnad in 1916 seem to have made further contributions to our knowledge in discussion of what purports to be an Akkadean tablet of the same period. This contains two approximations for the length of the diagonal of a right triangle in terms of the sides.

Since the publication by the British Museum in 1900 of part IX of its "Cuneiform Texts from Babylonian Tablets" (*i.e.*, CTIX), it has been known that two tablets 85194 and 85210 contained nearly fifty mathematical problems. Till recently, however, no one could translate and interpret them. It now appears that to Dr. Neugebauer, of Göttingen, author of a monograph "Zur Entstehung des Sexagesimalsystems" in the Göttingen *Abhandlungen* (1927), must be given the credit for notable achievement not only in this regard, but also in making illuminating comment on mathematical parts of Sumerian and Babylonian texts recently published by Carl Frank in *Schriften der Strassburger Wissenschaftlichen Gesellschaft in Heidelberg*, new series, Heft 9. Some of his results are to be found in the first issue of a new publication, *Quellen und Studien zur Geschichte der Mathematik*, of which Neugebauer, Julius Stenzel, of Kiel, Otto Toeplitz, of Bonn, are the editors. This publication is to be issued in two parts, *Abteilung A: Quellen; Abteilung B: Studien.* The first part of the *Studien*, published in Berlin last April, contains new information of great interest to the student of Babylonian mathematics. This information is to be found in two articles, one by Neugebauer, "Zur Geschichte der babylonischen Mathematik," pp. 67–80; and the second by Neugebauer and Struve, "Über die Geometrie des Kreises," pp. 81–92. The first article is mainly taken up with the discussion of some problems of Frank's monograph with certain references to CTIX. Various problems connected with figures which may be derived by lines drawn parallel to a side of a right-angled triangle are discussed. In this way we get a series of trapezia (using this term as employed by every country of the world except the United States). The Babylonians and Egyptians were perfectly familiar with the fact that the area of a trapezium, such as this, is one half the sum of the parallel sides times the distance between them. One of the extraordinary conclusions arrived at in this connection is that the Babylonians of about 2000 B. C. seem to have known what is equivalent to our well-known formula for the solution of a quadratic equation of a certain form.

The second paper, apart from consideration of matters of terminology, mainly elaborates various problems of CTIX. The interpretation of one passage regarding a circle of circumference 60 and diameter 20 leads to a value 3 for π, also familiar to readers of the Bible (I *Kings*, 7, 23; II *Chronicles*, 4, 2). With this value of π the expression for the area of a circle seems to have been correctly derived by what is equivalent to the formula one twelfth of the square of its circumference. Similarly for the volume of the frustum of a right circular cone from the equivalent of the formula, one half the sum of the areas of the bases times the distance between them. In the discussion of chords of a circle it seems to be definitely suggested that Babylonians were familiar not only with the Pythagorean theorem but also with the fact that the angle in a semicircle is a right angle.

Such results regarding mathematics of nearly four thousand years ago are surely very extraordinary. It has been announced that a complete discussion of the mathematical part of CTIX is to be given in a part of *Quellen*. Its publication must be awaited with the keenest interest.

In 1928 I was informed by a noted Assyriologist that there are other Babylonian tablets which, on first reading, seem to indicate that the problems have to do with finding three parts of a triangle when three other parts are given. This, and results referred to above, suggest that the surmise with which this note opens may indeed come true, namely that it may not be very long before we know more about Babylonian than about Egyptian mathematics.

RAYMOND CLARE ARCHIBALD
BROWN UNIVERSITY

BIOLOGICAL PUBLICATIONS IN AMERICA

IN his communication on "Biological Publication in America" in SCIENCE for March 8, your correspondent fails to take into account an important phase of the matter. One reason the biologists find publication both slow and difficult is that so many of them take up a lot of valuable space with most circumstantial accounts of work that often turns out to be but a slender contribution to our knowledge. Each feels it his duty to give a history of the project, a detailed account of his own methods and a list of all the works he has consulted.

Like other things, the cost of printing has advanced to unwarranted heights during recent years and the high mortality among biological publications that are not financed by outsiders is sufficient indication that the publishers of such journals are not getting rich.

If publishers had to depend on the average "research" paper to keep their subscription lists growing, there would soon be few biological journals in existence. Ask yourself how many of these published researches you read carefully if they are not in, or

bordering on, your special field. And ask yourself how many people there are in your field who will care to read these selected papers through. Certainly not enough to keep any technical publication running, especially if the interested readers largely peruse it in the university or public library!

There is, however, it seems to me, a simple way out of the dilemma. It is this: let the authors of research papers offer to the scientific journals, an adequate statement of anything new that their researches have discovered, in the meantime sending their more circumstantial papers to some depository where they may be consulted. Should a worker at a distance wish to see the entire paper, there are various inexpensive means by which copies of it can be made. The great trouble is, at present, that publications are filled with details that only the very few read, although the cost is as great as if everybody read them.

Moreover, the omission of all the harrowing details will serve to brighten up the technical journals, add to the subscription lists, decrease the cost of publication and interest an ever-widening circle of readers in all sorts of research problems.

WILLARD N. CLUTE,
Editor of the *American Botanist*

INTESTINAL PROTOZOA AND CECAL MATERIAL IN RATS

HEGNER[1] has recently reported that chicks normally evacuate the contents of the cecum, and that this material may be distinguished from intestinal material. The latter is "usually compact and dark in color, whereas the cecal contents are more liquid and yellowish in color." He reports that intestinal protozoa are almost entirely localized in the cecum, and accordingly diagnostic samples may be obtained by the mere selection of the fecal matter. Something of the same nature appears to be true of the albino rat. The feces of the rat are usually hard and black in color, or a dark brown which becomes black shortly after voiding. If the animal is disturbed, however, by unusual handling, shaking or rapping the metal cage, or, best of all, by merely holding it by the tip of the tail while it struggles to escape, a series of defecations usually results, of which the last are soft and yellowish. And, as Hegner reports for the chick, in the rat these soft and yellowish masses are richer in cecal protozoa than the normally passed feces. Presumably the excitement accelerates the movement of the contents through the lower part of the intestine.

DAVID CAUSEY

UNIVERSITY OF ARKANSAS

FORBESICHTHYS FOR FORBESELLA

IN the thirteenth edition of Jordan's "Manual of Vertebrates," the new generic name *Forbesella* Jordan and Evermann is proposed for transitional species of Cave-fishes "connecting *Chologaster* with *Typhlichthys*"—*Chologaster papillifer* Forbes type.

We are informed by Mr. Gilbert P. Whitley that *Forbesella* is preoccupied. The name *Forbesichthys* Jordan and Evermann will replace *Forbesella*.

DAVID STARR JORDAN

SPECIAL CORRESPONDENCE

GEOLOGICAL MAP OF NEW MEXICO

A TWO-SHEET geological map of New Mexico, prepared by N. H. Darton on the basis of work chiefly done by many other observers and edited by G. W. Stose, has lately been published by the U. S. Geological Survey on a scale of 1:500,000 in twenty-two formation colors and with 100 meter contours. It is therefore a valuable supplement to the one-sheet map of Arizona published on the same scale and in thirty-two colors four years earlier (1924) by the national survey in cooperation with the Arizona Bureau of Mines. Explanatory bulletins to accompany the maps have been prepared by Darton.

A recent automobile trip across long stretches of both these states from Tucson to Albuquerque and return, with the maps in hand, has enabled me to appreciate their great value not only in setting forth in a general way all that has been thus far learned of Arizonan and New Mexican areal geology, but also in providing a basis for further local work on a more detailed scale. A few of the more striking features shown on the New Mexico map may be here noted. The south central part of the state is traversed by the San Andres range in a gently flexed meridional course seventy-five miles in length, between the broad alluvial plain of Tularosa "Valley," famous for its White Sands, on the east, and the but little narrower alluvial plain of the Jornada del Muerto on the west. The range is a monocline, with a belt of fundamental crystalline rocks along its eastern base, overlaid by a west-dipping series of Paleozoic strata. It is continued northward by the shorter Oscura Range, an east-dipping monocline thirty miles in length, a little offset to the east, the two ranges being separated by a broken-down anticline which trends obliquely to the north-northwest; hence the crystalline complex lies along the western base of the Oscura Range and the Paleozoic strata there slant down to the east. The oblique course of the broken anticline between the

[1] SCIENCE, 69: 432–434.

two ranges thus exemplifies a characteristic of the class of fault-block mountains to which these ranges seem to belong and for which Gilbert long ago found a type example in Nevada. Taken together the two ranges would seem to offer, except for their arid surroundings, a fine subject—especially around their intermediate anticlinal area—for field study by a group of ambitious young geologists, among whom topography, stratigraphy, petrology, paleontology and physiography might be shared.

An altogether different problem is presented by the great Tertiary volcanic area in the midwestern part of the state and its vast extension into the adjacent part of Arizona. The earlier cones are now greatly dissected and degraded; and the earlier lava flows, which at the time of their outpouring must have sought the lowest ground they could reach, are now frequently isolated in cliff-rimmed mesas 500 or 1,000 feet above the surrounding worn-down lower land. On the other hand, the youngest flows, following modern valleys or spreading over low flats, seem to be but few centuries old, so little weathering have their black, rugged surfaces experienced. This indicates that the time interval between the first eruption and the last is long compared to the time since the last eruption, and thus suggests that still other eruptions may take place in the near geological future.

The relation of this great volcanic field to the prevolcanic topography of its region is interesting. In a number of the high-standing mesas, the capping lava sheets are seen to lie unconformably on the evenly beveled surface of gently inclined strata, thus showing that the land surface of their time had been broadly degraded to low relief, as has been explained by Robinson,[1] and that it must therefore have then stood at a decidedly lower altitude than to-day. The earlier eruptions appear to have obstructed the drainage of the broad lowland, for deposits of unconsolidated sands and gravels are frequently found between the worn-down land surface and the later lava flows. Subsequently the still later cones and flows extended so far as completely to obliterate the preexistent drainage over some thousands of square miles; hence its place has been taken by new drainage systems consequent upon the slopes of the volcanic surface. It is by the headwaters of these new systems that the intervolcanic basins, which abound in New Mexico, have been smoothly aggraded with volcanic detritus during the later periods of eruptive activity and since its cessation. The treeless basin plains vary from five or ten to nearly one hundred miles across. Some of them are drained eastward to the Rio Grande, and those which are nearest to that river are now fairly well dissected. Others are drained northward by head branches of the Little Colorado, but most of the basins are given southward outlets by the headwaters of the Gila.

The deep dissection of parts of the volcanic area by some of the last-named streams has been made possible by a regional uplift whereby the former lowland of degradation, which may, as it stood far inland, have had an altitude of 2,000 or 3,000 feet, has been raised to altitudes of 6,000 or 7,000 feet, while the dissected cones of the volcanic cover now rise in places to altitudes of 9,000 or 10,000 feet. The present position of the continental divide hereabouts appears to have been defined by this upheaval in combination with the accidental distribution of the heavy volcanic masses on the former lowland. Similarly, the group of much-worn cones known as the White Mountains in eastern Arizona and their extension into New Mexico appear to have cut off the former southern heads of the Little Colorado and handed them over to the Gila system; and it is a part of the drainage area thus gained by the latter river that now supplies the reservoir of the famous Roosevelt dam, upon which the irrigation of the magnificent Phoenix oasis depends. Indeed, the White Mountains not only divert the drainage of a considerable area to this admirable purpose, but by their considerable altitude they provoke an increase of rainfall for the streams to carry off through their deep canyons, and furthermore by reason of their altitude the mountains catch a good share of rainfall which, if it fell toward lower ground, would evaporate in the thirsty air during its fall.

It is to the north of the west-central volcanic area of New Mexico that one comes upon the unsymmetrical dome of the Zuni Mountains and, a little farther to the east, the grand volcanic tableland around the dissected cone of Mt. Taylor. Taken together, these two unlike areas include a long and varied sequence of geological formations, from the fundamental crystalline complex in the unroofed center of the dome to the beveled Cretaceous strata under the Mt. Taylor lava flows. Although both areas were described in a general way years ago by Gilbert and Dutton and later in more detail by others, they merit closer study than has yet been given to them; hence here again is a district in which a party of advanced students of geology might find glorious opportunity for investigation—a district more conveniently situated than the arid San Andres range, as it has forests on the higher slopes, contains many ranches and towns and is traversed along its valleys by a railway and a highway. The Zuni dome very naturally defines, in its area, the

[1] H. H. Robinson, "The Tertiary Peneplain in Arizona and New Mexico," *Amer. Journ. Sci.*, 24: 109–129. 1907.

general location of the continental divide, one of the most interesting points of which lies to the north of the dome center between the heads of two competing streams on the wide floor of a subsequent valley that they have excavated along a belt of weak shales. To the south the underlying and stripped Shinarump and Permian strata rise toward the dome center; to the north the Wingate and higher strata stand up in three-story cliffs; the first brick-red member always excites the wonder of transcontinental travelers by rail or highway as they pass near its successive salients.

Each of the two bulletins above referred to[2] contains, first, a section on systematic geology in which the successive members of the geological column are concisely described; and second, accounts of the structure of selected areas. The bulletin on New Mexico, from the overlong title of which the first part should have been omitted, is a compendious handbook, exceptionally well illustrated and indexed. It must become, like the map, an indispensable companion for all geologists who enter the state.

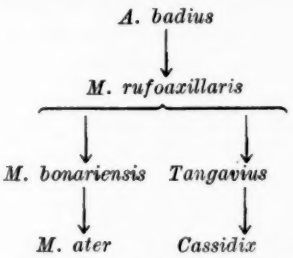
UNIVERSITY OF ARIZONA W. M. DAVIS

SCIENTIFIC BOOKS

The Cowbirds, A Study in the Biology of Social Parasitism. By HERBERT FRIEDMANN. Charles C. Thomas, 1929. 421 pp., 29 pls., 13 text-figs.

ALTHOUGH this book contains the results of only a portion of Dr. Friedmann's researches on parasitic birds, it probably represents the most important contribution to ornithology within recent years. It is, moreover, of no little interest to the parasitologist and entomologist. The parasitic behavior which consists in ovipositing in the nests of alien species and leaving them to rear the resulting young has been observed in members of no less than five natural families of birds: the cuckoos (Cuculidae), cowbirds (Icteridae), weaver-birds (Ploceidae), honey-guides (Indicatoridae) and ducks (Anatidae). The present work, which is confined to a detailed field-study of the cowbirds, with an account of their geographical distribution, taxonomy and ontogeny and an extensive citation of the pertinent literature, is an admirable demonstration of the kind of ethological investigation that has to be accomplished before the physiologist or experimentalist can even approach the fundamental problems of parasitism.

The cowbirds are a rather compact group of American Icterids comprising three genera: Agelaioides, with two species and three subspecies; Molothrus, with three species and ten subspecies, and Tangavius, with two species and three subspecies. One species of Agelaioides and one of Tangavius are known only from a few museum specimens. The greater part of the volume consists of an account of *A. badius, M. rufoaxillaris* and *M. bonariensis* which Dr. Friedmann was able to observe in Argentina, of *M. ater,* which he studied very thoroughly in the United States, and of *T. aeneus,* which he observed in southern Texas. There is one other Icterid parasite, the neotropical rice grackle, *Cassidix oryzivora,* to which a short appendix is devoted. The study of geographical distribution, habits (especially courtship and song) and the ontogenic development of coloration all indicate that the phylogenetic relationships of the parasitic Icterids conform to the following scheme:



The baywinged cowbird, *A. badius,* which occurs in Argentina, Uruguay, Paraguay, Bolivia and southern Brazil, is the most primitive form of the series and is non-parasitic, except to the extent that it appropriates, either peacefully or by force, the nests of other birds, particularly those of wood-hewers, spinetails and oven-birds (Anumbius, Synallaxis and Furnarius). It may still exhibit the nest-building instinct, especially early in the breeding season, and usually adds to or rearranges the materials of the nests of which it takes possession. Its breeding instincts are still intact. Dr. Friedmann regards it as the direct ancestor of the screaming cowbird, *M. rufoaxillaris,* the parasitic habits of which were first studied by W. H. Hudson. This bird has the same range as *badius* and lays its eggs almost exclusively in the appropriated nests of its putative ancestor. The shiny cowbird, *M. bonariensis,* with its eight geographical races, or subspecies, ranges over nearly the whole of the South American continent and has become a general parasite on a large number of birds. Its eggs have been found in the nests of ninety-eight different species, eighty-four of them being parasitized by the typical subspecies *bonariensis* alone. Hudson and Friedmann observed occasional abortive attempts at nidification in the shiny cowbird. It pecks holes in the eggs of its host. Its own eggs show great

[2] N. H. Darton, "A Résumé of Arizona Geology," Bull. 110, College of Mines, University of Arizona, 1925; and by the same author, "Red Beds and Associated Formations in New Mexico, with an Outline of the Geology of the State," Bull. 794, U. S. Geol. Surv., 1928.

variation in color, form and size. According to Hudson, it lays from sixty to one hundred eggs in a season, but Friedmann finds that the number is only six to ten. Several females may lay in the same nest. In one nest of a rufous oven-bird Leo Miller found thirty-seven eggs. "As many as thirteen different cowbirds have been found to lay into the same nest in one of these extreme cases late in the season." This intensification of parasitism is due to the great abundance of *M. bonariensis* as compared with the North American *M. ater* ("certainly twice as abundant"). *M. bonariensis* also destroys or even devours a great many eggs of its own species when it finds them in a nest.

> In this way, in regions where the cowbirds are exceedingly common and checks upon their increase at the expense of the rest of the bird population are lacking, the species acts as a check upon itself. If it did not the rapid increase of the cowbirds in any locality would soon cause a scarcity of hosts, which would in turn cause a diminution in the number of young cowbirds raised, which in turn would give the fosterers a chance to increase again, and so on in an endless series of waves of depression and inflation of the population both of the parasite and its victims. This egg-pecking habit tends to maintain a normal, instead of a shifting, status of bird population.

Dr. Friedmann believes that the egg-pecking had its origin in the habit of throwing out the eggs of the host.

The most nearly complete study—a veritable monograph in itself—in the volume is on our North American cowbird, *M. ater*. Though evidently of neotropical origin, this species and its three subspecies are now confined to southern British America, the United States and temperate Mexico. Many interesting facts are recorded in regard to its distribution, migration, courtship, eggs and egg-laying, the development of the young, their instincts and plumage, the moults, food and association with cattle in the adults, the relations to other birds, longevity, etc. The sections on the hosts and relations to cattle will be read with particular interest. All the host records have been conscientiously collated with the result that the cowbird is now known to lay its eggs in the nests of 195 different birds belonging to 158 species, 103 genera, twenty-five families and eight orders. Of course, the successful rearing of the young depends on the character of the chosen host. It must be an altricial species with eggs of about the same size as those of the cowbird and possess similar habits of feeding its young. Sometimes the cowbirds lay in the nests of birds with habits too aberrant to act as foster-parents, such as hawks, doves and swallows. Nests in holes are usually avoided. The only families of Passerine birds not known to be parasitized are the shrikes (Laniidae), dippers (Cinclidae) and wagtails (Motacillidae). The dippers breed at too high an altitude and only one species of wagtail breeds within the cowbird's range. The Corvidae (crows and jays) have too large eggs. Of the 195 different host birds listed by Dr. Friedmann, ninety-one have been definitely recorded as rearing the young parasites. Some birds, *e.g.*, the robin, catbird and yellow-breasted chat, absolutely refuse to tolerate the eggs. The robin and catbird toss them out of the nest and various vireos, warblers and the redstart build over them. Many birds desert their nests if the cowbird lays in them first, and the yellow-breasted chat does this even if it has eggs of its own and notwithstanding the similarity of the eggs of the two species. The majority of the species, however, seem not to notice the presence of the cowbird eggs and proceed to rear the hatching young. As a rule the cowbird lays only a single egg in a nest and while the owner is away. Moreover, it rarely lays in a nest containing partly incubated eggs or hatched young. Often the host eggs fail to develop or disappear (probably thrown out by the young cowbird).

> When some of the rightful eggs hatch the young are usually starved or suffocated by the young cowbirds, although nests are occasionally found in which one or more of the young survive together with the interloper. . . . The young cowbird usually tries to trample on the other young in the nest and to this extent the death of the rightful young may correctly be attributed to the volition of the parasite. The question of starvation is, however, somewhat different. Birds do not feed their young in any definite sequence but always feed the one that seems hungriest first. Hunger is expressed by the food-reaction, *i.e.*, the elevating of the head and opening of the mouth with the associated food calls. The bird with the longest neck and biggest mouth gets the food, and the cowbird usually answers these requirements. Naturally endowed with an ample length of neck and size of mouth, the cowbird usually possesses two additional advantages over its nest-mates. First, it is larger to begin with, thereby enabling it to raise its head higher, and second, it usually hatches a day or so before any of the others and thus gets a start on them.

The cowbird owes its name to its frequently observed association with cattle, the bison formerly, and domestic kine, horses and sheep at the present time. The various interpretations of this association which is most apparent from midsummer to the time of the autumn migration of the birds are discussed and the conclusion is reached that, contrary to the opinion usually held, the cattle themselves do not provide the birds with an adequate supply of food in the form of ticks, flies, bot-fly larvae, etc., but as they move about the pasture stir up the grasshoppers,

leaf-hoppers, etc., and thus facilitate their capture by the birds. Grasshoppers and leaf-hoppers appear to be the cowbird's favorite food, the former constituting 11 per cent., the latter 45.1 per cent. (in August) of the stomach contents that have been investigated.

> All these insects are naturally hidden in the grass and would be difficult for the cowbird to obtain were there not some agent to cause them to jump up and reveal themselves. The grazing action of the buffaloes (or the cattle) provides exactly such an agency. The animals do not cause or bring about a supply of food for the birds but help them to find the stores of food existing all around them.

This is very probably the correct explanation, and reminds the reviewer of his experiences while walking through thickets in New Zealand in 1914. After entering the vegetation he was often accompanied by a small fly-catcher (Rhipidura), which was so tame as almost to alight on his sleeve or insect net. At first he was inclined to regard this as an exhibition of extraordinary friendliness, but soon noticed that the bird was merely acting as his *fidus Achates* in order to feed on the midges and small moths which he stirred up in his progress through the shrubbery. Subsequently the same species of fly-catcher was seen accompanying grazing cows in the same manner and with the same object.

The account of the red-eyed cowbird, *Tangavius aeneus,* which inhabits Central America and tropical Mexico and enters the southern border of the United States, is rather brief. This bird was studied by Dr. Friedmann in the Lower Rio Grande Valley.

> The red-eyed cowbird victimizes relatively few species of birds. The various species of orioles seem to be the chief hosts of this parasite. When we consider that of all the species in the genus Molothrus, the screaming cowbird, *M. rufoaxillaris,* is the nearest relative of the red-eye, this restriction of the parasitism of the latter to relatively few species becomes particularly interesting. The screaming cowbird is parasitic almost solely on the bay-winged cowbirds, its closest relative, while the red-eye, not having any non-parasitic cowbirds to victimize, has taken to using the nests of an allied genus, Icterus, to a very large extent. It is also gradually widening its sphere of activity to include more and more genera and species and at present is known to victimize eleven genera and seventeen species and subspecies, but about 75 per cent. of all the eggs are laid in nests of Orioles. I have data on seventy-six victimized nests all in all and of these no less than fifty-one belong to four species of Icterus.

The rice-grackle, *Cassidix oryzivora,* which looks like a larger edition of Tangavius, ranges (with three subspecies) from Southern Mexico to Paraguay, Southern Brazil and Missiones in Argentina. Its parasitic habits were first observed by Goeldi (1897) in Brazil, where it lays its eggs in the nest of *Ostinops decumanus* and *Cassicus perseus.* Chapman has recently observed it on Barro Colorado Island, Panama, victimizing *Zarhynchus wagleri.* Other hosts in South America are *Gymnostinops montezuma* and *Ostinops cristatus.* Apparently the young Cassidix does not always starve out the host young.

To the general reader the closing chapter of the book on the origin and evolution of the parasitic habit in the cowbirds will prove to be the most interesting. After reviewing the various authors from Aristotle to F. H. Herrick, G. M. Allen and E. Chance, Dr. Friedmann is inclined to accept Allen's view that parasitism has arisen independently in each of the various groups (cuckoos, cowbirds, weaver-birds, honey-guides and ducks). He calls attention to the fact that

> All the cowbird's closest relatives are nest-builders; in fact, its family, the Icteridae, is known as a family in which the nest-building instincts reach their pinnacle of development. . . . Within the genera Agelaioides and Molothrus we find several stages in the evolution of parasitism exhibited by different species. The bay-winged cowbird, *A. badius,* uses other birds' nests and lays its eggs in them but incubates and rears its own young. Sometimes it makes its own nest. The shiny cowbird, *M. bonariensis,* is parasitic but has the parasitic habit very poorly developed, wasting large numbers of its eggs. Rarely it attempts to build a nest but in this it is never successful. This indicates that originally it built a nest but no longer knows how. The North American cowbird, *M. ater,* is entirely parasitic but is not wasteful of its eggs. The screaming cowbird, *M. rufoaxillaris,* carries the evolution of the parasitic habit in a different direction to some extent in that it tends more towards specificity in hosts.

Since all the cowbirds establish breeding territories but show a diminishing tendency to defend them *pari passu* with the development of the parasitic habit, it is inferred that the breaking down of this instinct, especially in the male, is the immediate cause of parasitism. Another factor in producing this singular behavior is a disharmony in the cyclical instincts of nidification and oviposition in the female, as suggested by Herrick. In most birds nidification, of course, precedes oviposition, but if the latter is hastened by physiological stimuli (sight of other birds' nests or eggs, etc.) the latter may become vestigial as in the Argentinian, or suppressed as in the North American species.

A question that can not be answered but that nevertheless keeps cropping up is whether parasitism originated very gradually in a large number of individuals comprising a group or a species or whether it began

after the fashion of a mutation in a very few individuals. There is much to be said for both sides but neither leads us to any definite conclusion. The processes and methods of evolution are clear until we attempt to study any single case.

To the entomologist Dr. Friedmann's studies are unusually suggestive because they disclose so many analogies with the parasitism of social insects (wasps, bees and ants). There are similar indications of an origin of parasitism in struggle and parasitism, of preference for single or multiple hosts, of a lapse of nidificatory behavior owing to precocious readiness for oviposition, and, in one case at least, of a derivation of parasitic from host species. This is clearly shown in the parasitism of *M. rufoaxillaris* on its ancestral species, *A. badius,* a condition strikingly paralleled among parasitic wasps, bumblebees and ants. In other respects, however, the cowbirds, cuckoos, etc., are more like certain non-social insect parasites, such as the Mutillids, Sapygids, Chrysidids, etc., because in these cases we are concerned merely with brood-parasitism as in the cowbirds and not also with an adoption of the mother parasite in the nests of the host as in the case of *Vespa austriaca* and *arctica* among wasps, the various species of Psithyrus among bumblebees and such parasitic ants as *Formica sanguinea, Polyergus, Anergates,* etc.

The volume is well printed though it contains some unfortunate typographical errors; the bibliography is ample and there is an excellent index.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A VIBRATO TONOMETER

THE recent recognition of the significance of the vibrato in artistic singing has created the need for an apparatus suitable for demonstrating the various forms which the vibrato may take and for carrying on psychological and esthetic experimentation on the perception of the vibrato. The vibrato tonometer has been developed for the purpose and is recommended to experimenters because of its simplicity, convenience and relatively inexpensive construction. With it a vibrato may be produced with the number of oscillations per second, extent of the frequency fluctuation, extent of the intensity fluctuation and frequency-intensity phase relation under separate control.

The apparatus consists of a pipe, similar to an organ pipe, enclosed in a partially sound-proof box. The frequency is varied by an oscillating movement of the plunger, and the intensity by a sliding door in the side of the box. The plunger and the door move back and forth at the same frequency. Both are controlled by scotch-links, which impart a sinusoidal form to their movements. The device is operated by a hand crank, and when turned in rhythm with a metronome, or other timing device, the rate of the vibrato produced can be very accurately controlled. The ratio of the pulleys is such that each revolution of the hand crank produces three vibrato cycles. Thus, by setting the metronome at a known number of beats per minute, a vibrato of any desired number of cycles per second can be produced.

Two scotch-links are used, one controlling the frequency and one the intensity fluctuation. They are mounted on opposite ends of the same shaft, which is turned by a belt from the hand crank. The use of adjustments on the pins of the scotch-links makes it possible to vary independently the amount of the frequency and intensity fluctuations, respectively, from zero to the maximum used in an artistic vibrato.

By changing the position of the scotch-links on the shaft with respect to each other, any phase relationship desired between the frequency and intensity fluctuations can be produced.

The device thus provides for the production of a vibrato with independent control of the extent of the frequency fluctuation, extent of the intensity fluctuation, rate and frequency-intensity phase relationship.

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LABORATORY USES OF ULTRA-VIOLET TRANSMITTING GLASSES

IT may be of interest to those who are not familiar with the special glasses, particularly those biologists and chemists who are studying the effects of ultra-violet on bacteria or on chemical decompositions and syntheses, to learn that satisfactory containers can often be blown of glass. The new glasses vary in short wave-length transmission limit from about 2500 A to 3000 A, so that within this range it is possible to study the effect of wave-length by employing test-tubes, flasks, etc., of different materials. Each container acts as a filter, making external filters unnecessary. Of course, for wave-lengths shorter than 2500 A quartz or else open containers would probably be employed.

I have recently had occasion to study the emission of the 2537 A mercury line under such a variety of conditions that a large number of very special shapes and sizes of discharge tubes was required. To have used quartz with the necessary graded seals or graded

joints with quartz windows would have been prohibitively expensive. Cemented quartz windows proved unsatisfactory because they could not be heated during the evacuation of the tubes. I therefore asked the glass blower to try one of the ultra-violet transmitting glasses, making it about as thin as the wall of an incandescent lamp bulb. He succeeded without great difficulty in joining it to ordinary glass through which the lead-in wires, from two to eleven in number, were sealed. With a few exceptions, the tubes did not crack, and in all cases the transmission of the desired mercury line was satisfactory.

Another fact of great importance in work of this kind deserves mention. One of the first objections raised to the use of ultra-violet transmitting glass was that its transmission might decrease with age, thus making the apparatus useless. This objection obviously was based on the popular notion that solarization, which occurs when such a glass is exposed to sunlight or to short wave-length arc radiation, destroys the properties which distinguish it from ordinary glass. Had this been true the experiments could not have been performed, for quantitative measurements had to be made. A careful study of the matter was made, therefore, to determine the nature of the solarization. My laboratory found that the depreciation in transmission was not serious, that it took place within a short length of time and that the deterioration then ceased so that the glass retained its characteristic properties indefinitely thereafter.

DONALD C. STOCKBARGER
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JUNE 14, 1929

SPECIAL ARTICLES

THE EFFECT OF X-RAYS ON BACTERIA

THE effect of X-rays on certain insects and plants seems to be a popular study at the present time. There seems, however, to have been but little work done on the effect of these rays upon pure cultures of bacteria.[1, 2, 3] The present report is the result of a preliminary study of the effects of irradiation on pure cultures of *B. coli* and *Erythrobacillus prodigiosus*.

The *B. coli* used was isolated from fresh sewage. Its morphology and cultural characteristics were studied in order to prove that it was true to type. The stock culture of *Erythrobacillus prodigiosus* was secured through Dr. F. W. Tanner, of the bacteriology department. The stock culture was "pepped-up" by growing it on agar slants at 20° C. It was transferred daily to a new slant. In this way young and active organisms were available for study. In all cases the characteristic red pigmented colonies developed in twelve hours. The bacterial suspensions which were irradiated were prepared by adding two small loops of the organisms, as removed from a single colony on an agar slant, to 200 cc of sterile physiological salt solution. In each experiment 10 cc of this suspension was added to sterile test tubes of the following specifications:

Soft glass with lip

Length	152.0 mm.
Diameter (inside)	18.0 mm.
Diameter (outside)	21.0 mm.

The test tubes containing the suspension of the organism were placed in an inclined position in an all-wood test tube rack and placed in the lead box containing the X-ray tube. The position chosen for the test tubes was the one which was most convenient and one which did not place the tubes in the beam from the X-ray tube directly perpendicular to the target in order that the effect might be slower and more easily followed. Immediately before starting the X-ray treatment one of the test tubes containing the suspension of the organism was removed and dilutions plated out to determine the original count per cc. The irradiation was then started with a tungsten target tube using a potential of sixty-five kilovolts and a current of three to four milliamperes. At certain time intervals test tubes were removed and dilutions plated out to determine the total counts. The analytical results are summarized in Table I. The rate of sterilization may be noted when the bacterial count is plotted logarithmically against time of irradiation.

RESULTS AND CONCLUSIONS

(1) X-rays act like sterilizing agents upon cultures of *B. coli* and *Erythrobacillus prodigiosus*, in that the curves are characteristic sterilization or death-rate curves showing that the total counts decrease logarithmically with time.

(2) In this experiment *B. coli* did not show variation or mutation when it was treated with X-rays.

(3) With increasing irradiation *Erythrobacillus prodigiosus* showed a tendency toward lack of ability

[1] "Recherches sur l'Action Bactericide des Rayons X," J. J. Trillat, Annales de l'Institut Pasteur, 41, 583 (1927).

[2] "Influence of Temperature on Biologic Action of X-rays," A. Dognon, Arch. Phy. Therapy, X-rays, Radium 9, 55–9 (1928).

[3] Production of Monochromatic X-rays of Long Wave Length," "The Quantum Action on Microbes," F. Holweck, Compt. rend. 188, 197 (1929).

to produce its characteristic red pigment. By allowing the organism to grow on the plate for a period of five days the greater portion of the colonies produced their pigment. If a transfer of a white colony is made to an agar slant the characteristic pigment is produced in twelve hours. In only one case was it necessary to make a second transfer in order to bring about the development of the pigment. The above is another example of the variation tendency of *Erythrobacillus prodigiosus*.

TABLE I
SUMMARY OF ANALYTICAL RESULTS

B. coli Data

Sample number	Time of irradiation in minutes	Total count per cc (24 hrs.–37° C.)	Remarks
1	0	70,000	
2	5	70,000	
3	15	17,000	Single colonies were picked from plate of sample number
4	30	9,000	6 and morphology and cultural characteristics were ex-
5	45	1,700	amined. All tests were characteristic of the original.
6	60	10	
7	90	0	

Erythrobacillus prodigiosus Data

Sample number	Time of irradiation in minutes	Observations of Glucose-Agar Plates			
		2nd day		3rd day	5th day
		Total count per cc 20° C.	Pigment	Pigment of colonies	Pigment of colonies
1	0	800,000	red	red	.....
2	5	600,000	red	red	.....
3	15	480,000	red	red	.....
4	30	400,000	red	red	.....
5	45	300,000	red	red	.....
6	60	45,000	80% white*	50% white	90% red
			20% red	50% red	10% white
7	90	400	100% white*	80% white	60% red, 40% white
8	120	0	.....	.....	.....

* All white colonies that were fished from the plates (12 in number) and streaked on agar slants produced luxuriant red pigmented growth at 20° C. in twenty-four hours with the exception of one colony fished from sample number 7 which failed to give red pigment until it was transferred to a second agar slant.

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MULTIPLE GLACIATION IN THE SIERRA NEVADA[1]

DEFINITE and conclusive proof of two stages of glaciation was found in the Sierra Nevada of California in 1913 independently by Knopf, on the east flank of the range, and by the writer, in the Yosemite region. The evidence consists primarily of two series, or bodies, of moraines, an older characterized by subdued, partly eroded forms and containing weathered, disintegrating boulders, and a younger characterized by well-preserved, sharp crests and containing mostly fresh, unweathered boulders. In addition both observers found erosional evidences of a roughly quantitative sort demonstrating that the interval between the deposition of the older and younger moraines was of the order of an interglacial stage.

The detailed mapping of the moraines of the Yosemite Glacier and its tributaries, however, soon enabled the writer to distinguish further subdivisions of the glacial record. Each of the two great bodies of moraines he found to be composite in its nature, so that together they embody a four-fold record—of two earlier and two later glacial advances. But

[1] Published by permission of the director of the U. S. Geological Survey.

whether each of these glacial advances represents a separate glaciation, or merely a major fluctuation of the glaciers, seemed at first uncertain. Comparative studies made in subsequent years on the morainal systems of the Tuolumne, San Joaquin, Kings and Kaweah glaciers, and revisits to the Yosemite region, however, have since tended to confirm the writer's opinion that the two later glacial advances occurred in relatively rapid succession and mark substages of a single—the last—stage of glaciation; whereas the two earlier advances were separated from each other by a long interval of time and mark two distinct stages of glaciation. Accordingly, there is on the west slope of the Sierra Nevada a definite record of three successive glaciations, of which the third and last had two climaxes. The general correctness of Willard D. Johnson's tentative recognition in 1905 of a triple glacial record in Bridgeport Valley, on the east side of the Sierra Nevada, is thereby borne out.

These proofs of multiple glaciation in the Sierra Nevada of course render desirable the finding of suitable names for the different stages. The last stage, to judge by the fresh appearance of its moraines and the excellent preservation of its glacier polish on rock surfaces, doubtless corresponds to the last glacial stage in the Rocky Mountains, and therefore is properly correlated with the Wisconsin stage of the continental ice. It scarcely needs a new name in the Sierra Nevada, and, therefore, in his reports on the Yosemite Valley and the San Joaquin basin the writer is referring to it as the Wisconsin stage. Its division into two substages would seem in harmony with the well-known division into distinct substages of the Wisconsin in the north-central parts of the continent. Still, the writer would not for the present dismiss altogether the possibility that what is here called the first substage of the Wisconsin in the Sierra Nevada may be the correlative of the Iowan.

The ice of the preceding, or second, glacial stage was much more extensive in the Sierra Nevada than the ice of the Wisconsin stage. Whereas the Yosemite Glacier of the Wisconsin stage terminated within the Yosemite Valley, as is attested by the frontal moraines above the Bridal Veil Meadow, the Yosemite Glacier of the second glacial stage reached ten miles farther down the Merced Canyon and terminated a short distance below El Portal, the entrance to the Yosemite National Park. Frontal moraines are lacking there, but the lateral moraines can readily be traced to the vicinity of El Portal, and beyond that place begin the remnants of a long valley train of outwash material that must have extended from the front of the glacier. The name El Portal stage therefore seems appropriate for this stage of glaciation (no more suitable name derived from a locality in any of the major glaciated canyons on the west flank of the range suggests itself).

The earliest of the three glaciations appears to be recorded in the Yosemite region only by erratic boulders occurring singly or in rows or groups, but without accompanying fine material, at levels one hundred to two hundred feet above the highest lateral moraines of the El Portal stage. They lie in places where there is every reason to believe that heavy, continuous moraines once were laid down. As the conditions there are on the whole favorable for the preservation of such moraines and as the boulders consist invariably of exceedingly resistant rocks, such as quartzite or highly siliceous granite, the conclusion seems inescapable that the boulders are the sole surviving remnants of moraines of a very early stage of glaciation that have wasted away almost completely. Such erratic boulders occur at a level about seven hundred feet above Glacier Point, extending in a row from the east base of Sentinel Dome to the north end of Illilouette Ridge. Others are scattered on the broad divide east of Mount Starr King. The extreme antiquity of the boulders above Glacier Point is attested also by the fact that, although they were carried by the ice only half a mile from their parent ledges, they have lost the angular forms of plucked blocks and have become rounded by long-continued exfoliation *in situ*. For this early stage of glaciation, accordingly, the name Glacier Point stage is proposed.

Correlation of the El Portal and Glacier Point stages with the generally accepted stages of the Pleistocene determined in the area of continental glaciation can scarcely be attempted at the present time. However, from the depth to which the granite on Moraine Dome, on the north side of the Little Yosemite, has disintegrated and wasted away since the El Portal glaciation—a minimum of seven feet, as is indicated by residual crags of resistant aplite—it may be judged that the time distance back to the El Portal stage is at least twenty times, and perhaps forty times, as long as the post-glacial interval and is to be reckoned in hundreds of thousands of years. The El Portal stage therefore probably corresponds to the Illinoian, and the Glacier Point stage, by inference, may correspond to the Kansan or even the Nebraskan.

Of particular interest in this connection is the recent discovery by Blackwelder at several points on the east front of the Sierra Nevada of what he regards as evidence of three, and possibly four, distinct glaciations. It is to be hoped that these may soon be definitely correlated with those recognized in the Yosemite region.

F. E. MATTHES

U. S. GEOLOGICAL SURVEY